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Annual Report

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DISCLAIMER

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Appendix ii — Cruise Report CONRAD Cruise 19 Leg 5

Appendix iii — Data Report "The New York Bight & Hudson Canyon in October 1974" by A.F. Amos

Appendix iv — Suspended Particulate Concentrations and Compositions in the New York Bight by P.E. Biscaye and C.R. Olsen — Removed

Appendix v — New York Bight Water Stratification-October 1974 by A.L. Gordon, A.F. Amos and R.D. Gerard — Removed

ABSTRACT

This is a report to the Energy Research and Development Administration on accomplishments of the Lamont-Doherty Geological Observatory geochemistry and physical oceanography groups during the 1975-1976 funding period on grant E(11-1)2185. Our goals are to obtain detailed, quantitative knowledge of the rates of mixing within coastal waters of the New York Bight and across the continental slope and the exchange of water masses and species transported within them between shelf and ocean waters. This research is aimed at understanding the chemical, physical and biological processes which control the origin, dispersal and fate of particulate matter, and to ultimately model the impact of energy related pollutants on the continental shelf.

The report is divided into four sections that correspond to like-numbered sections in the accompanying renewal proposal: (1) a general introduction; (2) spreading of water characteristics and species in solution; (3) mixing and dispersal of solids and trace metals and (4) mixing of species across, within and out of sediments. Each section has its own introductory statement followed by a report on field work accomplished, analyses done and results of our findings to-date. While a broad division within these sections separated physical oceanograpy and geochemistry we have attempted to show how these two main efforts are being integrated to form a comprehensive program to apply to the problem of understanding the fate of energy-related pollutants.

Section 5 is a list of papers published, in press or in preparation and talks given during the 1975-1976 funding period that acknowledge the support of this ERDA grant. Five appendices are included: (i) and (ii) are preliminary reports from CONRAD cruises 19-01 (July 1975) and CONRAD 19-05 (January 1976); (iii) is the text of a data report (now in press) on VEMA 32-01 (October 1974) physical oceanography with examples of each of the data sets; (v) and (vi) are reprints of two papers, both in press (Limnology & Oceanography), that are an outcome of our 1975-1976 research effort.

1.0 INTRODUCTION

1.1 The L-DGO Program of Research in the New York Bight

The geochemistry, physical oceanography and marine biology groups at Lamont share an interest in the mode of operation of continental and coastal water systems. Our research is aimed at understanding the processes which control the transport of dissolved and detrital materials through these systems. To do this requires the simultaneous study of physical mixing, sediment dynamics and biological activity. The present research program was begun in July 1974 as an integrated geochemical-physical oceanographic study of circulation, transport and transfer rates in waters of the New York Bight. In the coming year we propose the addition of a small complementary effort in marine biology. The region under investigation includes the Atlantic coastal waters of Long Island and New Jersey extending seaward across the continental shelf and into the waters of the upper continental slope.

The goals of the Lamont-Doherty investigation in this area are:

- To obtain detailed, quantitative knowledge of the rates of mixing within coastal waters (including the Hudson Estuary) and across the continental slope, and the exchange of water masses and species transported within them between shelf waters and adjacent ocean water masses.
- By improved, quantitative knowledge of the chemical, physical and biological processes which control the origin, dispersal and fate of particulate matter, to understand and ultimately be able to model the impact of energy-related pollutants on the continental shelf.

Since the outset of this research, the design of our program has been within three general guidelines:

(1) To utilize geochemical and physical oceanographic techniques and methods (many of them developed by Lamont-Doherty workers in studies of the deep ocean) which have not previously been employed in continental shelf studies in order to improve our ability to examine

complex, short-term features of stratification and mixing.

(2) To concentrate these techniques and methods to study features of the circulation on areas not presently being investigated by other research groups.

(3) To focus upon processes which control the fluxes of particulate matter in the water column and in the sediments because most energy-related pollutants of concern to ERDA and the people of coastal areas are associated with particulate phases.

Within these guidelines our approach to the problem may be seen in the organization of this report, viz. first, consideration of techniques designed to understand processes that control the water column and its properties; second, techniques designed to understand the behavior of particulate-associated pollutants; and third, techniques designed to understand the role of the sediments as a sink for pollutants. An overview of this three-pronged approach is as follows.

First, the water column:

a. The distribution of temperature, salinity and dissolved oxygen. This conventional approach provides the foundation for all other studies. Unless water masses are identified, verticaly density gradients are established and the seasonal variability in these distributions is known there is little chance of working out the transport of particles through the water column. Through the use of an STD we are getting a far more detailed picture of these structures than is possible from the traditional Nansen cast approach (discrete temperature and salinity data).

b. The use of O^{18} as a conservative tracer. The source of the low salinity components to coastal waters is not well understood. While much comes from the local rivers it is suspected that major currents coming from the Laborador Sea must also contribute. It is essential to sort out the local (hence polluted) fresh water component from the northern (hence unpolluted) component. As described below, O^{18}-S diagrams offer a means to do this.

c. The use of Ra^{228} as a natural latteral mixing tracer. The other component of shelf water is, of course, the open ocean and it is important to establish the rate of latteral mixing between coastal waters and those of the adjacent open ocean. This process presumably contributes to the ultimate removal of pollutants from the coastal environment by exchange with the open ocean. Ra^{228} provides a unique means of getting at this question, a means which is strengthened by our recent work on its chemical sibling, Ra^{226}. This nuclide has a half life so much greater than that of Ra^{228} (1600 yr vs. 6 yr) that, in the exchange between coastal and open ocean water, the former can be considered to be stable. Both are generated within coastal sediments and diffuse into the overlying water. The primary fate of Ra^{228} is transport as a dissolved species into the adjacent open ocean and radioactive decay. An analysis of our success to date in deriving information from the distribution of these tracers is summarized below.

d. The use of Rn^{222} as a dispersion tracer. The fine-grained sediment on the shelves is the host for reactive pollutants and a potent source of radon gas. Most of the shelf is covered with coarse-grained sediment. The pockets of fine-grained sediment are by comparison quite small. We have been looking at the relationship between water column distribution of the radon gas emitted from these pockets and the geometry of the pockets themselves. In a sense, we get a measurement of the dispersion of one week's time (the mean lifetime of Rn^{222} atoms) of substances added to the water column from the pockets of fine-grained material. Combined with estimates of the particulate concentrations in the water column and settling rates of these particles it should be possible to model the rate at which particles are being carried away from these sites. As most of the pollutants of concern are borne by these particles, by measuring radon we are gaining an insight into pollutant fluxes as well as quasi-Lagrangian estimates of short-term water mixing.

Second, the distribution and chemistry of particles suspended in the water column:

a. Besides measurements of the spatial and temporal distribution of particulate concentrations, we are attempting to identify particles of compositions that are useful as tracers of particle dispersal paths. In this connection, the dump sites for sewage sludge and acid waste provide an important point source. Aided by the capability to do semi-quantitative chemical analyses of individual particles we are seeking to establish movement patterns. Of particular interest in this connection is the role of the Hudson canyon as an outbound conduit for New York area pollutants. Sediment coring, filtering of discrete water samples, Coulter Counter size distributions and <u>in situ</u> light scattering measurements are all components of the field program.

b. The distribution of anthropogenic radionuclides such as Cs^{137}, Pu^{239} and Co^{60} as measured on large quantities of particulate matter filtered from the water column and on sediment samples provides valuable adjunct tracer information regarding sediment transport paths and accumulation sites. We are also attempting to exploit naturally-occurring nuclides to study particulates by carrying out field studies of the distributions of two short lived isotopes of thorium generated within the water column. Th^{234} is generated by the U^{238} dissolved in coastal waters. It has a 25 day half life. Th^{228} is generated by the Ra^{228} dissolved in coastal waters. The daughter-parent activity ratio in the water column is a measure of the chemical removal rate constant, i.e.

$$\frac{A_{daughter}}{A_{parent}} = \frac{\lambda radio}{\lambda radio + \lambda chem}$$

We have shown from these measurements that the chemical removal time ranges from 1 to 80 days and shows well-defined seasonal cycles and geographic patterns.

c. Beyond simply determining the bulk removal rates of pollutants, we would like to determine how this removal is accomplished. How much is due to the incorporation into living organisms followed by excretion to the sediment and how much is due to inorganic uptake onto the suspended particles? The strong seasonal dependence of removal time already suggests that the removal is related to the activity of planktonic organisms.

And third, the sediments as a sink for pollutants:

a. Pollutant particles at the sediment-water interface are still potentially active in the system by resuspension. Therefore, the rate at which sediment is mixed downward by benthic mixing is an important step in pollutant dispersal. Several anthropogenic and naturally-occurring radionuclides are available for studies of these rates.

b. Once mixed or buried downward in the sediment column, some chemical species are still potentially active by diffusion back into the water column. In some cases we must understand such fluxes back into the water column to make complete budgets of pollutant behavior but, in the cases of some naturally-occurring radioactive tracers, we must quantitatively know these fluxes as the source term in modelling the behavior of these tracers in the coastal water system.

Our field program over the first two years has been based around the conduct of seasonal cruises aboard the major Lamont-Doherty research vessels. The concept of using large research ships in coastal work is contrary to tradition and may be explained as follows: because of the complex stratification of shelf waters and their rapid seasonal changes and shorter-term perturbations, work must be done at closely-spaced stations along closely-spaced transects in the shortest possible time in order to obtain a quasi-synoptic view of a significant area. Furthermore, because of the need for simultaneous measurements by a variety of techniques, a large multidisciplinary team of scientsits with extensive shipboard laboratory facilities is a fundamental requirement. These requirements can only be met by the largest and most capable of research vessels. Our experience in this regard is supported by a recent UNOLS study for future research vessel needs. It may well be that the tradition of assigning continental shelf research to the smaller vessels has impeded progress in this area.

In terms of our overall shelf program we are now in the position of having collected a large, but as yet incomplete, data set based on a seasonally-oriented survey of the New York Bight. As suggested in Tables 1 and 2 we have collected an enormous number of samples, a small portion of which have been analyzed, and a great deal of data not all of which has been reduced, much less assimilated.

TABLE 1

ERDA RESEARCH CRUISES, NEW YORK BIGHT

CAST SUMMARY

CAST TYPE	VEMA 32 Leg 1 16 Oct - 31 Oct, 1974	CONRAD 19 Leg 1 19 Jul - 4 Aug, 1975	CONRAD 19 Leg 5 4 Jan - 21 Jan, 1976	Totals
STD	58	60	81	199
HYDRO	-	4	-	4
RADON	35	65	81	181
FILTER	12	2	-	14
PUMP	60	121	78	259
NEPHELOMETER	13	38	32	83
CAMERA	9	14	3	26
SHIPEK GRAB	41	73	80	194
PISTON CORE	2	1	5	8
GRAVITY CORE	2	1	9	9
3" SANDERS CORE	-	8	-	8
6" SANDERS CORE	-	2	-	2
PLANKTON TOW	-	-	13	13

TABLE 2

ERDA RESEARCH CRUISES, NEW YORK BIGHT

SAMPLE AND SHIPBOARD ANALYSIS SUMMARY

SAMPLE TYPE	VEMA 32 Leg 1 16 Oct - 31 Oct, 1974	CONRAD 19 Leg 1 19 Jul - 4 Aug, 1975	CONRAD 19 Leg 5 4 Jan - 21 Jan, 1976	TOTALS
SALINITY	778	1333	1129	3240
OXYGEN	473	1016	472	1961
PHOSPHATE	82	584	472	1138
SILICATE	82	584	472	1138
NITRATE	82	-	-	82
NITRITE	82	-	-	82
AMMONIA	82	-	-	82
RADON	255	490	627	1372
SUSPENDED PARTICULATES (FILTER-GRAVIMETRIC)	300	438	551	1289
SUSPENDED-PARTICULATES (SIZE-COULTER COUNTER)	-	505	650	1155

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1.2 Work Accomplished during the 1975-1976 Period

During the 1975-1976 funding period we made two research cruises on R/V R. D. CONRAD (see cruise reports, appendices, i, ii). Each cruise followed the same basic track initiated in our first cruise on R/V VEMA in October 1974 (appendix V, Figure 1) i.e. three main transects from the inner Bight, normal to the isobaths extending out to the slope to about the 2600 m isobath. One transect follows the Hudson Shelf Channel and Canyon axis and the other two fall on either side of the canyon over a relatively smooth part of the shelf and slope. A number of stations were run across the canyon and shelf channel linking the three main transects.

We have made it a policy to modify our cruise plans wherever our experience or the results obtained indicates that such changes would enhance the program. For example, from the October 1974 cruise results it was obvious that concentrating stations over a relatively narrow distance either side of the shelf channel and canyon did not allow us to adequately contour features of the water column and sediment distribution that appeared to be related to the geography of the channel/canyon axis. Consequently on the July 1975 cruise (CO-19-01) several stations were spread out between the three transects which resulted in a less-biased data set (while still revealing several parameters that showed a canyon-related trending). This expanded station coverage on the shelf showed that in addition to the region of high excess-radon along the shelf channel and canyon related to the areas of sedimentary fines (see Biscaye and Olson, appendix iv), another excess-radon source was associated with the "mud-hole" south of Block Island.

On our January cruise (CO-19-05) we therefore occupied a line of stations eastward to 70°W and were able to delineate this zone and confirm the source and the distribution of excess-radon in the water column.

Another change in our field techniques has been to include time-series STD profiling in addition to single-profile stations. This was first tried in the July cruise where a rather abrupt horizontal change in the bottom temperature and salinity represented the extent of slope water penetrations onto the shelf. This was an attempt to detect internal surf activity (see Gordon, Amos and Gerard, appendix V). In January a more ambitious time-series measurement was made alternating between two locations over a 25-hour period. Repeated radon, particulate and nephelometer casts were made coincident with each STD profile.

With each subsequent cruise we have been able to increase the number of stations and samples collected (see tables 1 and 2). This has been due to our becoming more experienced with the special problems of making frequent shallow stations, producing many samples for on-board analysis with little steaming time between casts.

Starting with the July cruise we initiated a nutrient (silicate and phosphate) sampling program running the samples on board using a Beckman DU spectrophotometer. In October 1974 cruise we collected only a few samples for nutrients that were frozen and analysed at L-DGO after the cruise. We reduced the number of bottom photography stations on both the July and January cruises to save time as numerous photographs of the area exist in the archives of various institutions. Only where special conditions warranted a photographic investigation, i.e. the Hudson Canyon at our current meter/nephelometer site, were additional pictures taken.

At the same time we increased the number of nephelometer profiles, taking them with all night-time and deep STD casts.

A 15-day current meter/ocean bottom nephelometer station was made during July 1975 at the same location as our September-October 1974 series. Although the current meter failed to produce useable data the nephelometer worked well and the data is now being analysed.

A modest biological program was undertaken during the January cruise consisting of Plankton tows and benthos sampling from the Shipek grabs (see appendix ii).

2.0 SPREADING OF WATER CHARACTERISTICS AND SPECIES IN SOLUTION

2.1 General Statement

Waters of the continental shelf are influenced by strongly contrasting forces. One side receives fresh river water, concentrated at a number of segments of the coastline, while at the other, there is interaction with open ocean water of unknown spatial and time characteristics. The surface waters are subject to dramatically altering conditions, not just on a seasonal time-scale, but even on a daily basis during passage of atmospheric fronts. The bottom boundary is highly variable, the continental slope being the greatest escarpment on the globe. Bottom conditions are further complicated by deep canyons cutting into the continental slope and channels on the shelf floor. The continental shelf water represents a relatively small volume of sea water which, because of the highly variable boundary conditions, possesses high parameter gradients which are subject to significant time variability.

Man naturally concentrates his interaction with the sea along the shores and thus impacts directly on the waters of the continental shelf. This trend will continue as utilization of the shelf waters increases in the coming decades. The primary increase in usage will be as waste-disposal sites and sites for the placement of energy-related systems such as nuclear power plants, petroleum refineries or petroleum drilling platforms. We must know the vigor of the exchange processes active within the shelf waters and at the boundaries to evaluate the problems stemming from energy-related contaminants--the goal of our ERDA project. Subtle inter-leaving of water characteristics, gradient changes of temperature and salinity against depth in temperature=salinity space, and presently being interpreted as having direct relevance to our understanding of the general ocean spreading of heat and salt. Inspection of chemical species (as dissolved gases or nutrients) in the light of STD data is further enchancing our new-found appreciation of striking deep-ocean inhomogeneities.

The STD data set--representative of the seasons and extending from the inner shelf, across the shelf break (with some concentration within the Hudson Canyon) to the upper continental rise--enables the Lamont-Doherty team to inspect the entire system with modern physical oceanographic methods.

The physical oceanographic data set is coupled with geochemical measurements to enhance the value of each. The primary tools of geochemistry within the water column are the stable isotopes of oxygen, $^{18}O/^{16}O$, and the naturally occurring radioactive isotopes radon-222 and Radium 228. To date, we have obtained STD data representing condition for October 1974, July 1975 and January 1976.

2.2 Physical Oceanography

The October 1974 data set (V-32-01, appendix iii) was presented at the ASLO meeting, and will be published in the symposia proceedings (see "New York Bight Water Stratification—October 1974", appendix v).

Our goals relate to the spatial and time change of water stratification. The time scales range from "down- to up-trace" (tens of minutes) including time-series sequence over a tidal period, to repeat station positions (weeks), to inter-cruise comparison (seasonal). The spatial scale relates to the role of the Hudson Canyon-channel system to cross-shelf and shelf-break processes.

2.2.1 October 1974 Hydrography

The October 1974 STD traces show the pycnocline (about mid-depth) to possess numerous temperature-salinity inversions which may be taken as signs of isopycnal stirring (Figure 3, appendix v). If this is the case, such a process would effectively transfer water found below the pycnocline over the inner shelf with water above the pycnocline over the outer shelf. This condition occurs because of the relative slope of isopycnal surfaces to the pycnocline brought about by the basic estuary character of shelf stratifications (Figure 4, appendix v). Pycnocline transfer processes may also be an effective mechanism for shelf-slope exchange, as suggested by the seaward extension of the cold shelf bottom water into the center portion of the pycnocline over the continental slope.

The october data set also indicates some interesting stratification patterns over the Hudson Canyon. The water characteristics suggest enhanced landward transfer over the canyon coupled with increased vertical mixing (Figures 5 and 6, appendix v). Landward spreading of slope water within and over the canyon (consistent with the canyon current-meter record; see appendix iii) may be an important element in the role of the canyon to the overall heat and salt budget of the continental shelf waters.

Another interesting shelf-slope exchange process revealed by the STD traces is the bottom intrusion of warm, saline slope water, replacing the cold, shelf bottom water (Figure 7, appendix v). This intrusion may be, in part, an abrupt event, perhaps a result of interaction of the internal tides and the shelf break (Patrie, 1975). The time-series STD data collected in January 1976 over the shelf break will be an important data set in evaluating this hypothesis.

2.2.2 Hydrography of the New York Bight in Summer 1975 and Winter 1975-1976

The data from both these cruises are still being reduced so only the broad results will be summarized here. Analysis of data from the winter cruise is more nearly complete because of our having been able to borrow a computer/data acquisition system for the cruise from the University of Rhode Island. The STD system functioned well during this cruise, whereas on the summer cruise problems with the salinity sensor have made data reduction a more difficult task.

The July-August 1975 surface temperatures ranged from 19°C in the inner bight south of Long Island to >26°C over the outer shelf and slope region. Bottom temperatures on the shelf ranged from 10°C in the near-shore waters down to 5-6°C in the mid-shelf region, and 12°C on the outer shelf. Surface salinities ranged from <31°/₀₀ at the bight apex to 35.8°/₀₀ in the slope water south of the Hudson Canyon. The surface salinity front near the shelf break is more sharply defined during the summer than it is in Winter, and in July 1975 a tongue of low-salinity water (∿33°/₀₀) extended well over the slope east of the Hudson Canyon. Almost 20 inches of rain fell on the New York City area in June and July 1975, compared to the normal 6.5 inches, and part of this low-salinity surface water may be a result of the abnormal precipitation and part to remnant spring run-off water, and subsequent entrainment of shelf water by a large anticyclonic eddy. Bottom salinities on the shelf were <32°/₀₀ near the bight apex and about 35.5°/₀₀ where the slope water maximum impinges on the shelf landward of the shelf break.

A strong pycnocline existed over the entire shelf region. Slope water, characterized by high temperature and salinity encroaches onto the shelf to about the 75-m isobath--in the mid-shelf region--at this season. Shoreward of this depth, a homogeneous layer of cold, fresh winter water overlies the shelf beneath the pycnocline, while progressing seaward of the 75-m isobath a thickening layer of slope water is found. Some very steep salinity and temperature gradients were found in this region extending all the way to the bottom. At some stations the temperature increased by 3.5°C and salinity increased by 1.5°/∘∘ in the bottom 15 m. As both temperature and salinity increases are mutually offsetting in their effects on density, these gradients do not represent a zone of high vertical stability.

At the boundary between the winter-water bottom regime and the intrusion of slope water, a 24-profile time-series STD station was made (12 down- and 12 up=traces). Initial analysis of the series does not reveal any obvious shifting of this bottom "front", but gradients are so steep that the STD instrumentation has difficulty in resolving structure in the salinity record due to thermal-lag problems.

South of the Hudson Canyon over the continental slope our southern transect took us into an anticyclonic Gulf Stream eddy. The STD profile near the center of this eddy was characterized by a 350-m thick layer of 15°C, 36.2°/∘∘ water beneath a narrow, intense pycnocline (see Gulfstream, August 1975). The upper water structure on the northern edge of the eddy consisted of a series of interleaving lenses of shelf and slope water types. One of the reasons for extending our study across the shelf break over the slope is to see if the frequently occurring eddies from the Gulf Stream provide a mechanism for transfer of oceanic waters onto the shelf.

STD profiles at this season near the shelf break and in the Hudson Canyon show the most complex water structures that we have seen so far in this study. Shelf water, particularly over the Hudson Channel and Canyon, extends seaward and forms a temperature and salinity minimum at about 65 m until it loses its identity by mixing, in this instance, with water of the Gulf Stream eddy.

Features like the eddy encountered on this cruise are transient during the two weeks spent on one of our seasonal cruises. The eddy was estimated to be moving southwest at about 3 km day^{-1} (Gulfstream, August 1975), so in terms of presenting a synoptic view of the water structure of the shelf/ slope region, the eddy presents an anomalous situation. However, this particular eddy (known as Eddy B; Gulfstream, December 1975) was tracked by satellite imagery from 31 October 1974 to 3 November 1975, travelling from south of the Grand Banks to Cape Hatteras. During the period of our summer cruise, it stalled somewhat south of the Hudson Canyon. The satellite imagery shows continuous entrainment of a Gulf Stream-slope water mixture on the western side of the eddy--a process that brings warm salty water shoreward, possibly onto the shelf.

The January 1976 cruise took place from 6 January to 23 January 1976. We had originally intended to make this cruise in mid-February at the height of the winter shelf regime, but a ship-scheduling change forced us to take the earlier dates.

Surface temperature varied from <6.0°C in the inner bight to 13.5°C at our most seaward station. Bottom temperature on the shelf was <6°C at the apex to ∿14°C where the slope water impinges on the shelf. A large tongue of warm water extended well onto the inner shelf south of Block Island. Only along the inner shelf was the water column well mixed. At mid-shelf locations a two-layered structure was encountered--a cold, fresh, mixed surface layer beneath which temperature and salinity increased sharply, often in the bottom 2-5 m of the water column. On the outer shelf, a thin mixed layer occurred above the shelf floor. South of Block Island, both temperature and salinity increased from surface to bottom with

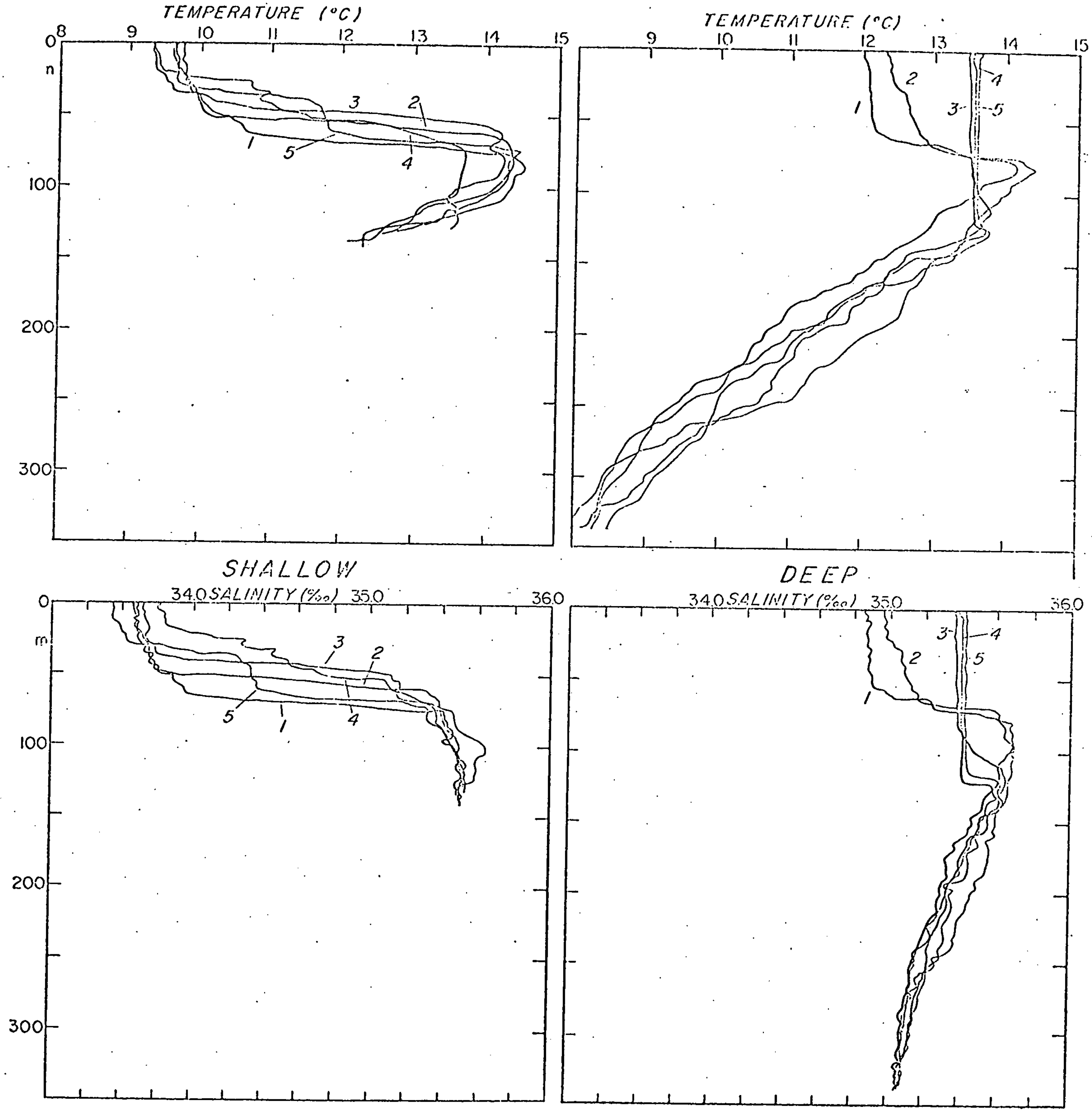

Figure 1

Temperature and salinity profiles taken over a 25 hour period at A (140 meters depth) and B (330 meters depth). The traces are labelled in Chronological order.

virtually no surface mixed layer. Surface salinity was lowest (31.5°/₀₀) south of Block Island. The slope front meandered shorewards over the Hudson Canyon, possibly the remnant of an anticyclonic eddy that was last detected on December 30, 1975 (Gulfstream, January 1976). Bottom salinities ranged from <32°/₀₀ where the salinity maximum is at the bottom at the 150-m isobath.

A time-series station was taken by making alternate STD casts on the outer shelf at 140-m depth, and on the slope at a depth of 500 m. A total of five casts (10 STD down- and up-traces) at each location over a period of 25 hours (Figure 1). Simultaneous nephelometer and radon casts were also made. At both locations, the depth to the pycnocline became shallower with time and then deepened again but did not reach its original position at the end of 25 hours after the first cast. In the slope station, the T and S profiles changed shape considerably after the third lowering. The temperature and salinity maxima virtually disappeared, indicating that the edge of the front where slope water is at the surface had moved inshore from its original location. Some difficulties were encountered in holding station at these locations and some of this change could have been due to ship's positioning error. We feel that these time-series will be most valuable in determining the time scales involved in any "spilling" of slope water onto the shelf.

2.2.3 Current Measurements in the Hudson Canyon

Two attempts have been made to obtain long-term current measurements in the Hudson Canyon. The first, in September and October 1974, resulted in a 53-day record of currents 5 m above the canyon floor at a depth of 827 m.

The second attempt, in July-August 1975 at the same location, failed due to a current-meter malfunction. (Both arrays included a long-term nephelometer and produced successful light-scattering data throughout the recording periods; see section 3.2.3.) Results from the September-October record have been presented at the 7th Annual Long Island Sound Conference in January 1975, and a paper is now being readied for publication (Amos, Baker & Daubin, in prep.).

We found that the mean flow in the canyon was almost due west at 2.75 cm sec^{-1}. This direction is up-canyon, although not parallel to the canyon axis at the array site. The conventional N-S and E-W vector components happen to be normal to, and in the direction of, the mean flow. This produces some interesting results: oscillations of tidal periods are observed in both components, yet in the E-W (along-canyon) flow the amplitude of the tidal peaks is much greater than in the cross-canyon flow (Figure 2). The semidiurnal (M2) period dominates in both direction; however, a diurnal (O2) peak is seen in the spectrum of the along-canyon component that is completely absent in the cross-canyon direction, while a fourth-diurnal peak can be seen in the cross-canyon spectrum but not in the along-canyon direction (Figure 3). The slopes of the spectra, toward the high-frequency region, are quite different; in the direction of the mean flow there is much more power in the high-frequency domain than in the cross-canyon spectrum. The slopes are approximately -3/2 and -5/2 for along-canyon and cross-canyon, respectively. Peak current vectors are $\sim$30 cm sec^{-1} up- and down-canyon, and $\sim$15 cm sec^{-1} cross-canyon.

The mean flow is up-canyon throughout the record. A low-pass filter applied to the along-canyon component to reject all oscillations with a period less than 48 hours shows that this up-canyon flow undergoes several long-term variations in amplitude. The spectrum shows two peaks at

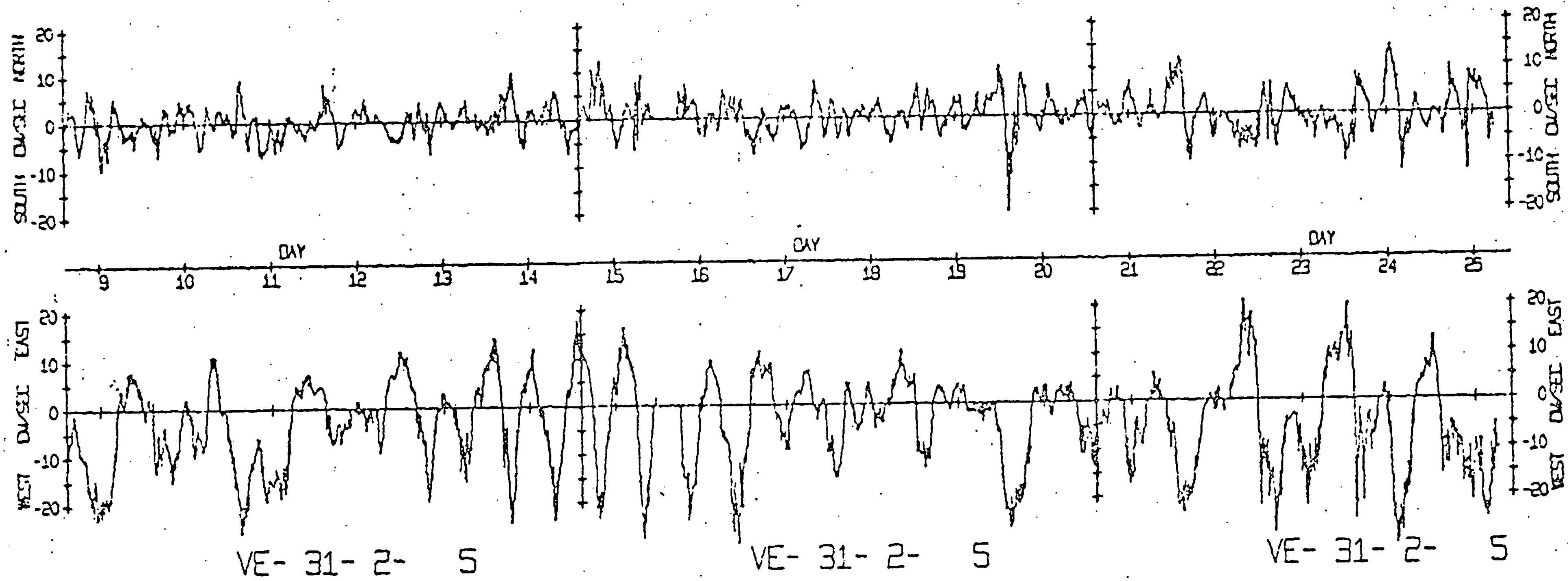

Figure 2

Vector components of currents in the Hudson Canyon in October 1975.

The upper trace is the north component.

The lower trace is the east component.

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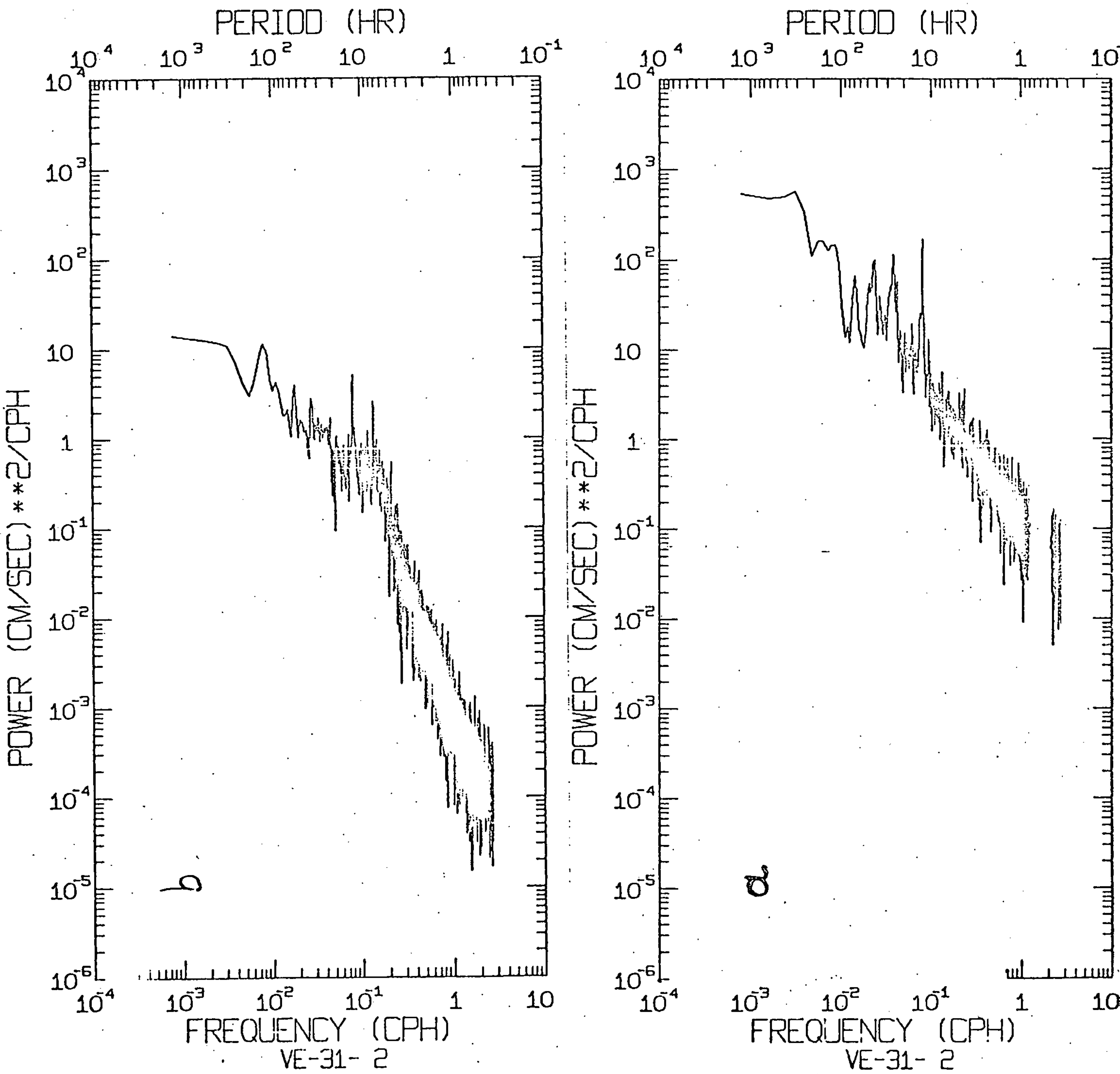


Figure 3

Power spectra of currents in the Hudson Canyon.

9a - the east component (along-Canyon flow).

9b - the north component (cross-Canyon flow).

approximately 42 hours and 70 hours. The longer of these two periods may be related to storm activity. There is also a much longer period (∿200 hours) that is too long to be adequately resolved as only six of these cycles occurred. No evidence of the inertial period (approximately 19 hours at this latitude) can be seen in either spectrum.

As part of our analysis of these data, we are comparing the canyon data with observations made of the tide at Ambrose Light during the recording period, and with meteorological data from land-based stations, to see if there are any obvious correlations between winds, barometric pressure and the observed long-period variations in the current record.

There is evidence from the September-October record of current and light-scattering that sediment is transported in both directions: a scatter plot of the along-canyon current vectors vs. light-scattering shows that the highest light-scattering values occur during up-canyon flow. In comparing the band-passed data in the diurnal and semidiurnal bands from both current and light-scattering, high light-scattering peaks in these frequency bands follow peak down-canyon currents with a lag time of from one to several hours. Thus the ebb and flow of tidal currents in the canyon may cause sorting of sedimentary particles and alternating patterns of up- and down-canyon sediment transport.

2.3 Geochemistry

2.3.1 $\delta\ O^{18}$-Salinity as a Tracer of Water Origins on the Continental Shelf

To date, more than 130 samples have been collected on the three New York Bight cruises for $\delta\ O^{18}$ analysis. In addition, an almost equal number have been collected from Georges Bank, South Atlantic Bight, the Hudson River, the Delaware River and the Nova Scotia coastal, slope and Gulf Stream waters. However, due to some minor but time consuming analytical problems, only the river and South Atlantic Bight samples have been analyzed. A nearly-complete overhaul of the Nuclide mass spectrometer is expected to eliminate these analytical problems.

2.3.2 Ra^{228} and Ra^{226} as Tracers for Rates of Lateral Water Mixing

Ra^{228} data from cruise VEMA 32-01 indicate that Ra^{228} diffuses from the shelf sediments into the overlying shelf water but the mixing time of water within the shelf break is much faster than the mean residence time of Ra^{228} in the shelf water ($\sim$ 0.6 yr) therefore, Ra^{228} concentration of the shelf water between 20 km from the coastline and the shelf break is quite uniform (9 $\pm$ 1 dpm/100 kg). The shelf water serves as a uniform source of Ra^{228} for the surface slope water and open ocean water. Within our present uncertainty of data, one can consider Ra^{228} either as a conservative tracer in surface water of the shelf and slope or a nonconservative tracer to estimate the horizontal eddy diffusion coefficient outside the shelf break (> 0.5×10^6 cm^2/sec).

In order to establish the usefulness of Ra^{228} as a tracer for the rate of lateral water mixing, we need more detailed Ra^{228} data across the continental shelf, slope and open ocean along with temperature, salinity and O^{18} measurements.

The Ra^{226} concentration in surface waters on the continental shelf is rather high (12.3 $\pm$ 0.9 dpm/100 kg) as compared to that of Atlantic open ocean water (7.5 dpm/100 kg).

If Ra^{226} and Ra^{228} have the same source function from the continental shelf, one would expect the activity ratio of ${}^{A}Ra^{228}/{}^{A}Ra^{226}$ in shelf water equal to the productivity ratio of Ra^{228}/Ra^{226} in shelf sediments, i.e. the activity ratio $\frac{{}^{A}Th^{232}}{{}^{A}Th^{228}}$ in the sediments at steady state. In fact, the observed ${}^{A}Ra^{228}/{}^{A}Ra^{226}$ ratio of the New York Bight shelf water is about 1.24 $\pm$ 0.14, and ${}^{A}Th^{232}/{}^{A}Th^{230}$ in Long Island Sound sediment is 1.25 $\pm$ 0.05 (Turekian, 1974). This is a surprising agreement, i.e. the source function of the two isotopes appears to be identical.

By analogy to the C^{14}/C dating method, one can estimate the average age of a water mass outside the shelf break by the relationship:

$$\left(\frac{A_{Ra}^{228}}{A_{Ra}^{226}}\right)_{slope} = \left(\frac{A_{Ra}^{228}}{A_{Ra}^{226}}\right)_{shelf} e^{-(\lambda Ra^{228} + \lambda Ra^{226})\, t}$$

$$\approx \left(\frac{A_{Ra}^{228}}{A_{Ra}^{226}}\right)_{shelf} e^{-(\lambda Ra^{228})\, t}$$

$$\therefore\ t = \frac{5.75}{0.693} \ln \frac{\left(A_{Ra}^{228}/A_{Ra}^{226}\right)_{shelf}}{\left(A_{Ra}^{228}/A_{Ra}^{226}\right)_{slope}} \qquad (1)$$

Where $(A_{Ra}^{228}/A_{Ra}^{226})_{shelf} = 1.24$ in the New York Bight shelf. Therefore, a slope water with $(A_{Ra}^{228}/A_{Ra}^{226}) = 0.62$, one calculates an average age of 5.75 years.

2.3.3 Radon-222 as a Tracer of Water Motions and Mixing

During the October 1974 cruise we measured 35 radon profiles (255 samples); during July 1975, 65 profiles (490 samples) and during January 1976, 81 profiles (627 samples). The July 1975 and January 1976 analyses provided much additional detail to the distribution of radon sources, and to the spreading of water from the sources.

In summary Ra^{222} data indicate: (1) the seasonal thermocline acts as a strong diffusion barrier preventing the loss of bottom-derived excess radon by evasion across the air-sea interface, i.e. under these circumstances the system can be considered closed (compare Figs. 4 and 5); (2) there exist on the shelf large geographic variations in excess radon concentrations and standing crops up to the thermocline (Figs. 6 and 7); (3) these local variations in the water column appear to be related to characteristics of the sediment, i.e. fine-grained sediments (clays and silts) are a much stronger source of excess radon than coarse, sandy sediments (compare Figs. 6-8 and 9): (4) the field observations related to sediment characteristics were confirmed by laboratory measurements of radon potential source strength on different sediment types (Fig. 10); (5) on the upper continental slope a zone of strong horizontal mixing exists throughout a water mass on the order of a kilometer thick which may be important in the exchange of shelf and slope water, particularly via the Hudson Canyon (Figs. 6-8).

The important conclusion from the sampling and analysis thus far is that there are on the continental shelf natural sources of a chemically-inert, radioactive tracer the scale length of which is comparable to important mixing processes of shelf water. We have measured the distribution of this tracer, radon-222, during three different seasons (different mixing regimes) and with sufficient areal and vertical density to have a reasonable basic understanding of its important sources, scales of transport from these sources and the

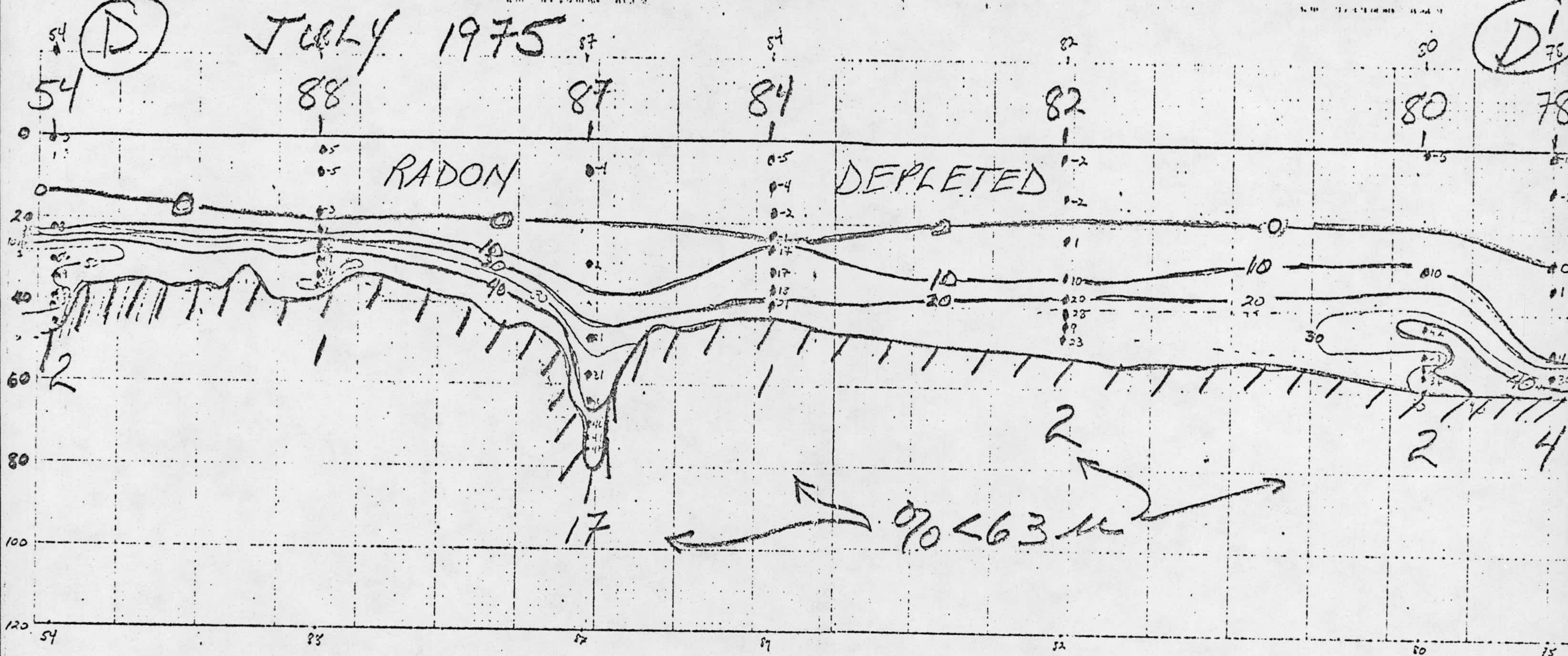
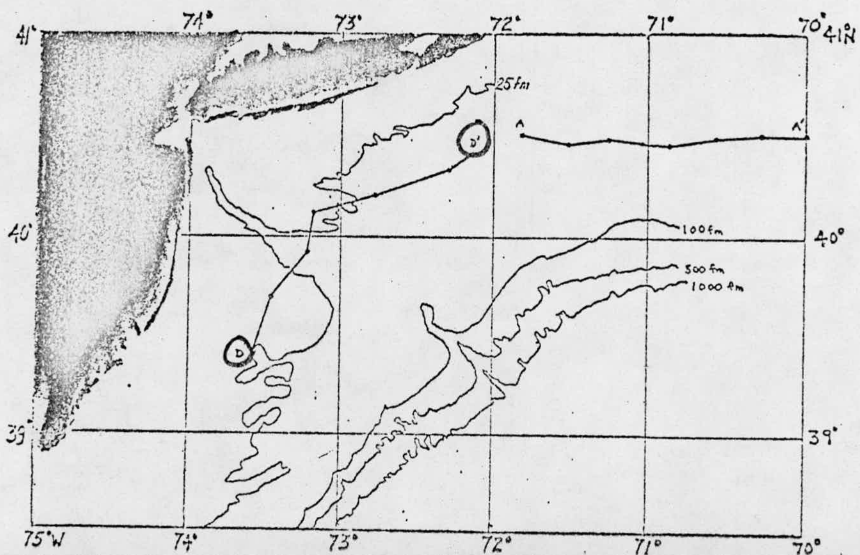


Figure 4

Excess radon section, New York Bight of July 1975 also showing the % < 63 μ in the bottom sediments. Note zero excess radon isopleth corresponds to thermocline depth.



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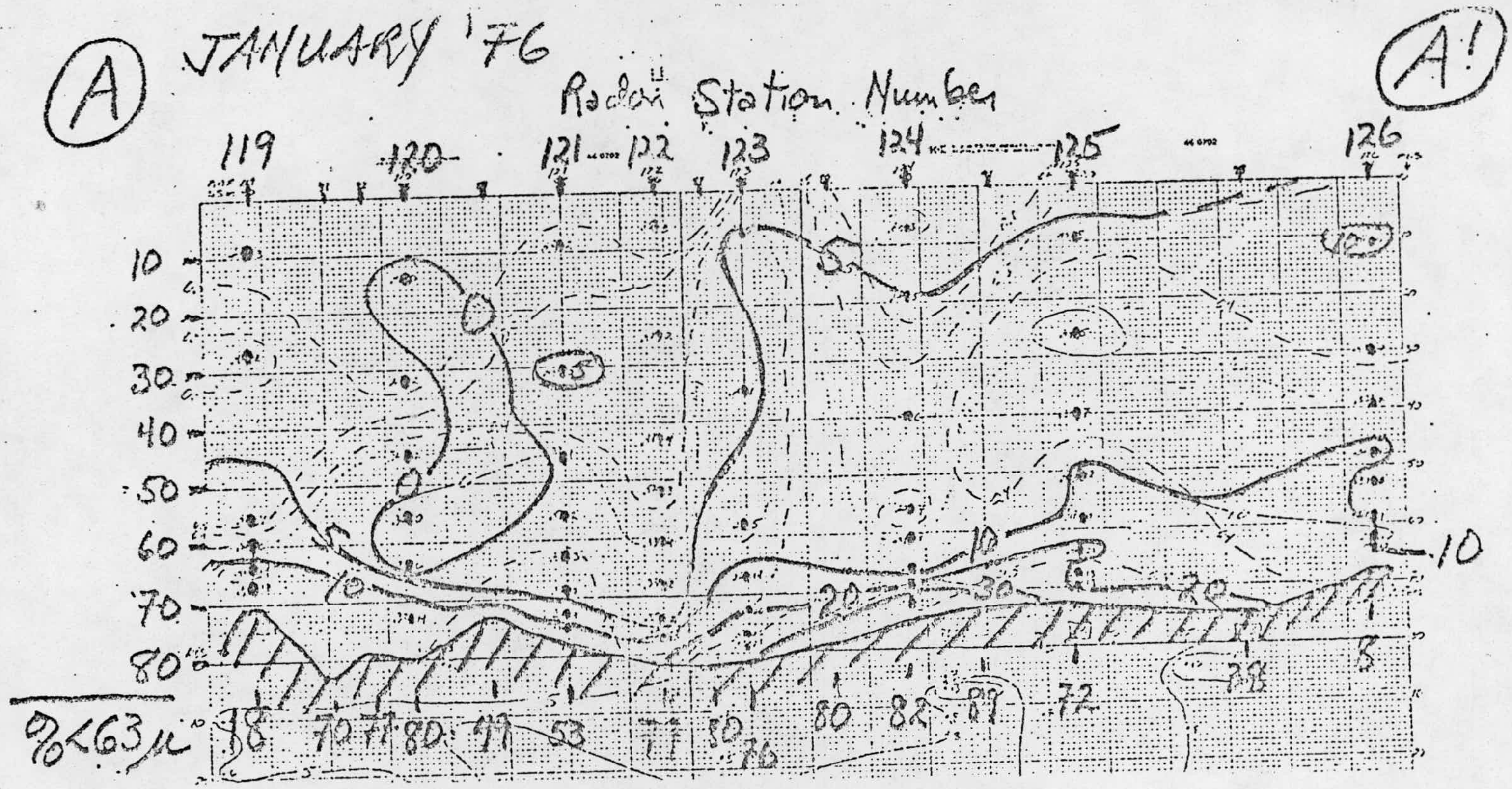
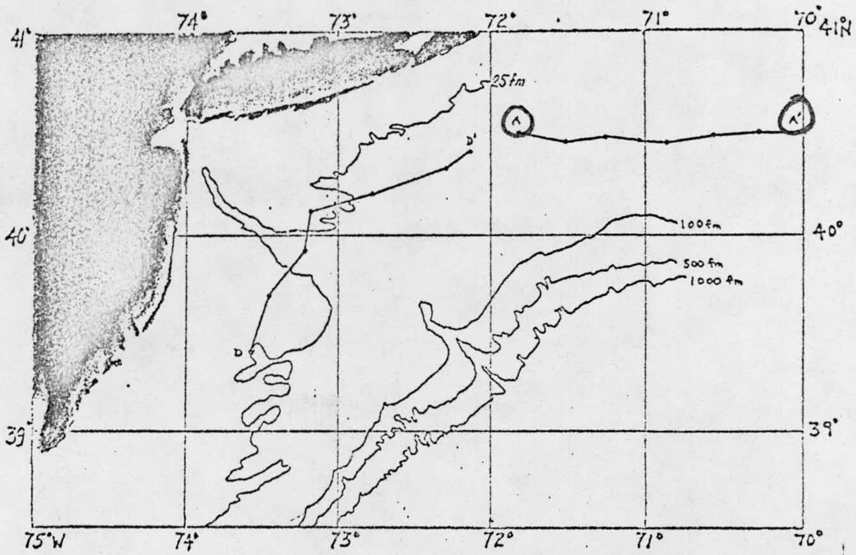


Figure 5

Excess radon section, New York Bight of January 1976 also showing the % <63 μ in the bottom sediments.



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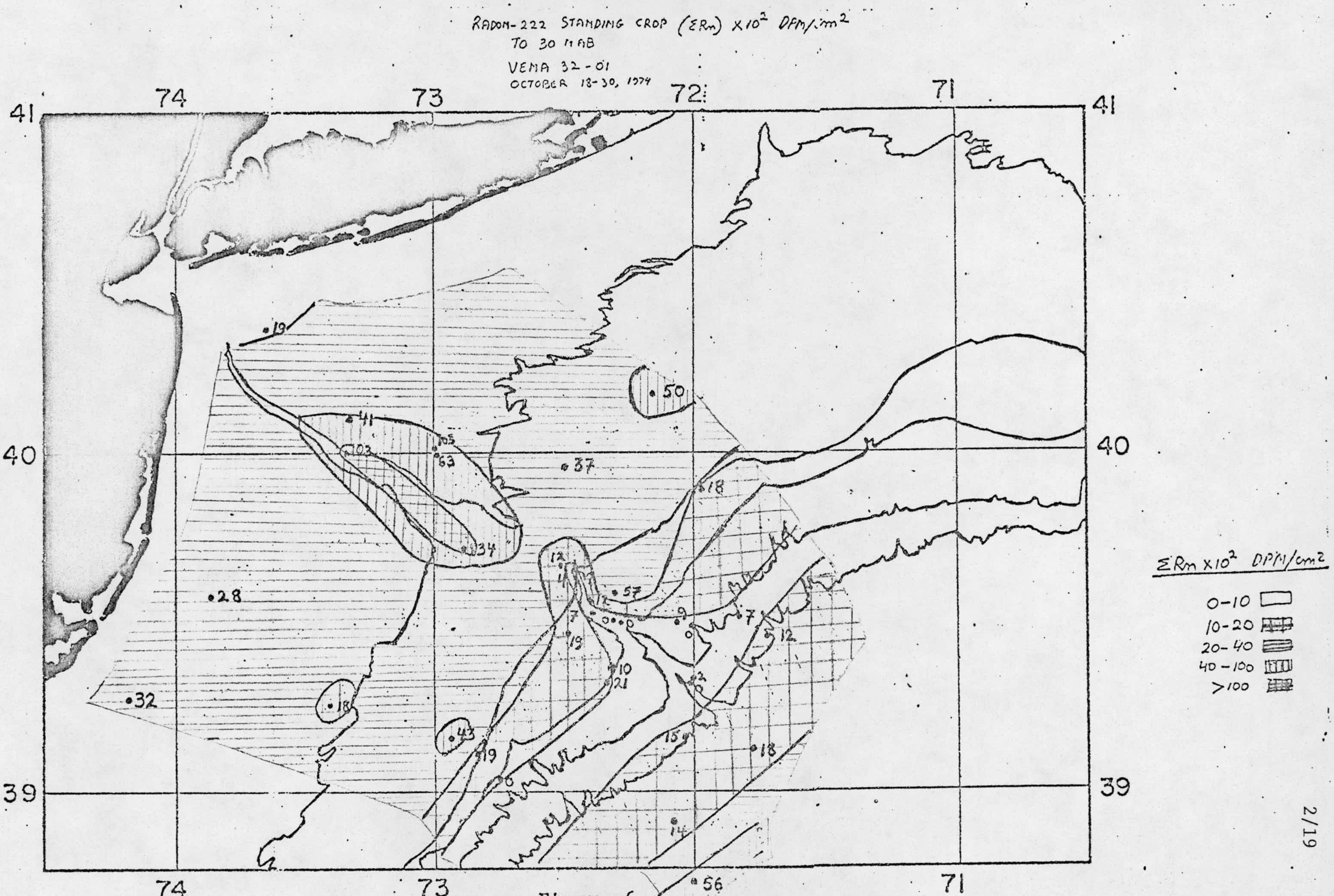

Figure 6

Radon-222 standing crop integrated up to 30 meters above bottom, October 1974, New York Bight.

RADON-222 STANDING ( ) (ΣRn) x10^2 DPM/cm^2
To 3 AB
CONRAD 19-01, JULY 1975

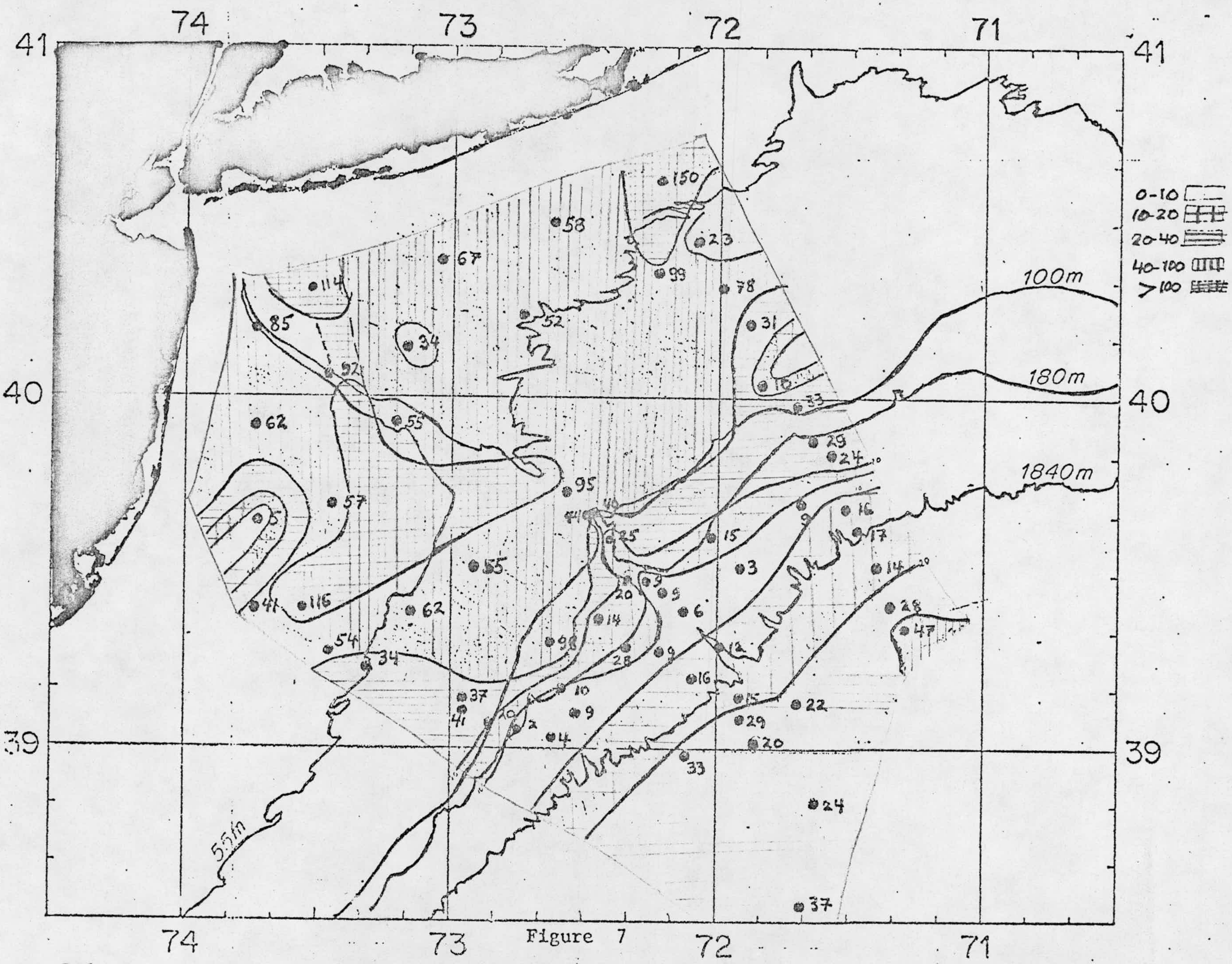

Figure 7

Radon-222 standing crop integrated up to 30 meters above bottom, July 1975, New York Bight.

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R C 19-05, JAN. 1976

RADON-222, STANDING CROP (ΣRn) $\times 10^2$ DPM/cm^2
TO 30 MAB

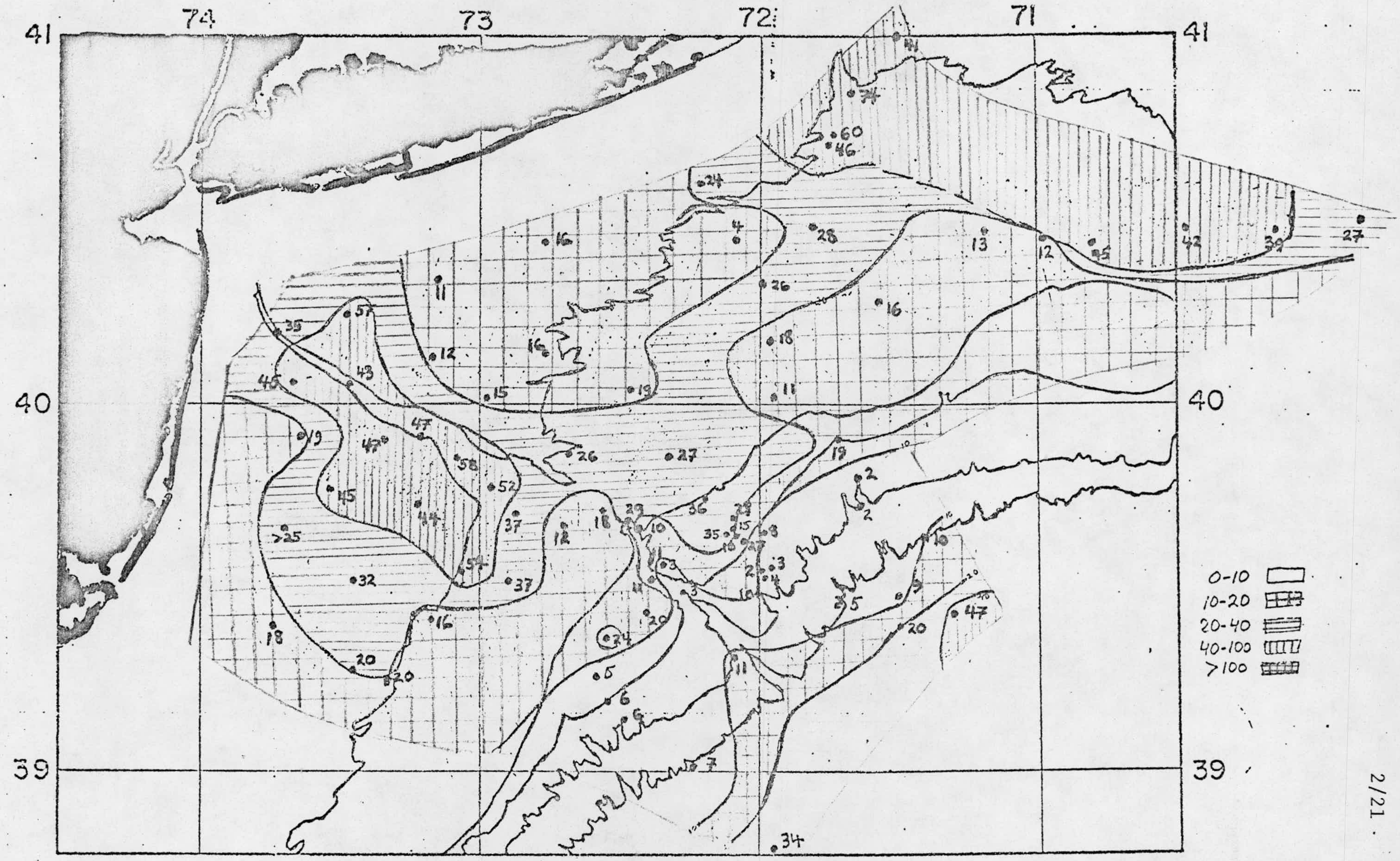

Figure 8

Radon-222 standing crop integrated up to 30 meters above bottom, January 1976, New York Bight.

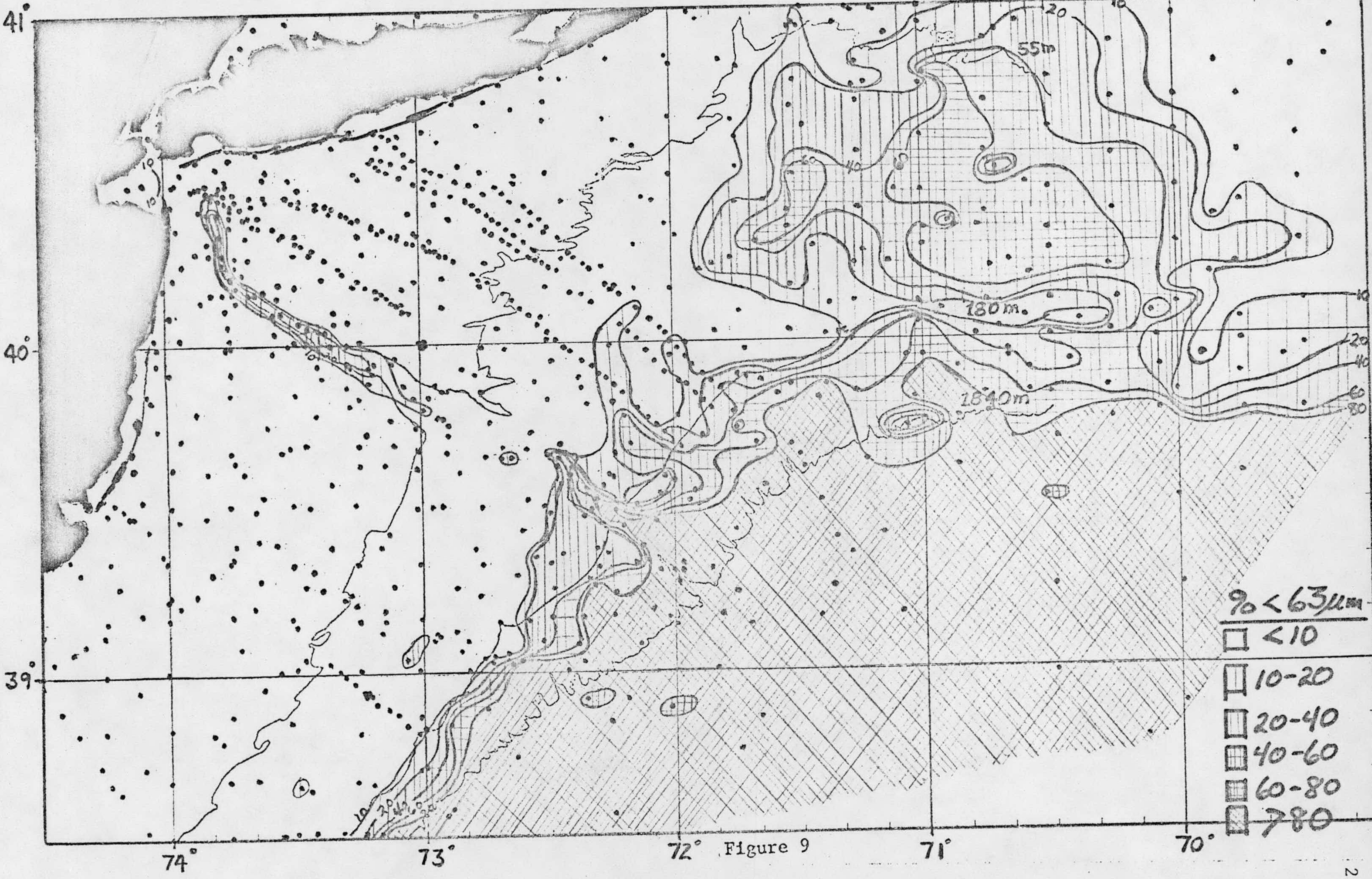

Figure 9

New York Bight, percent fraction smaller than 63 microns in bottom sediments.

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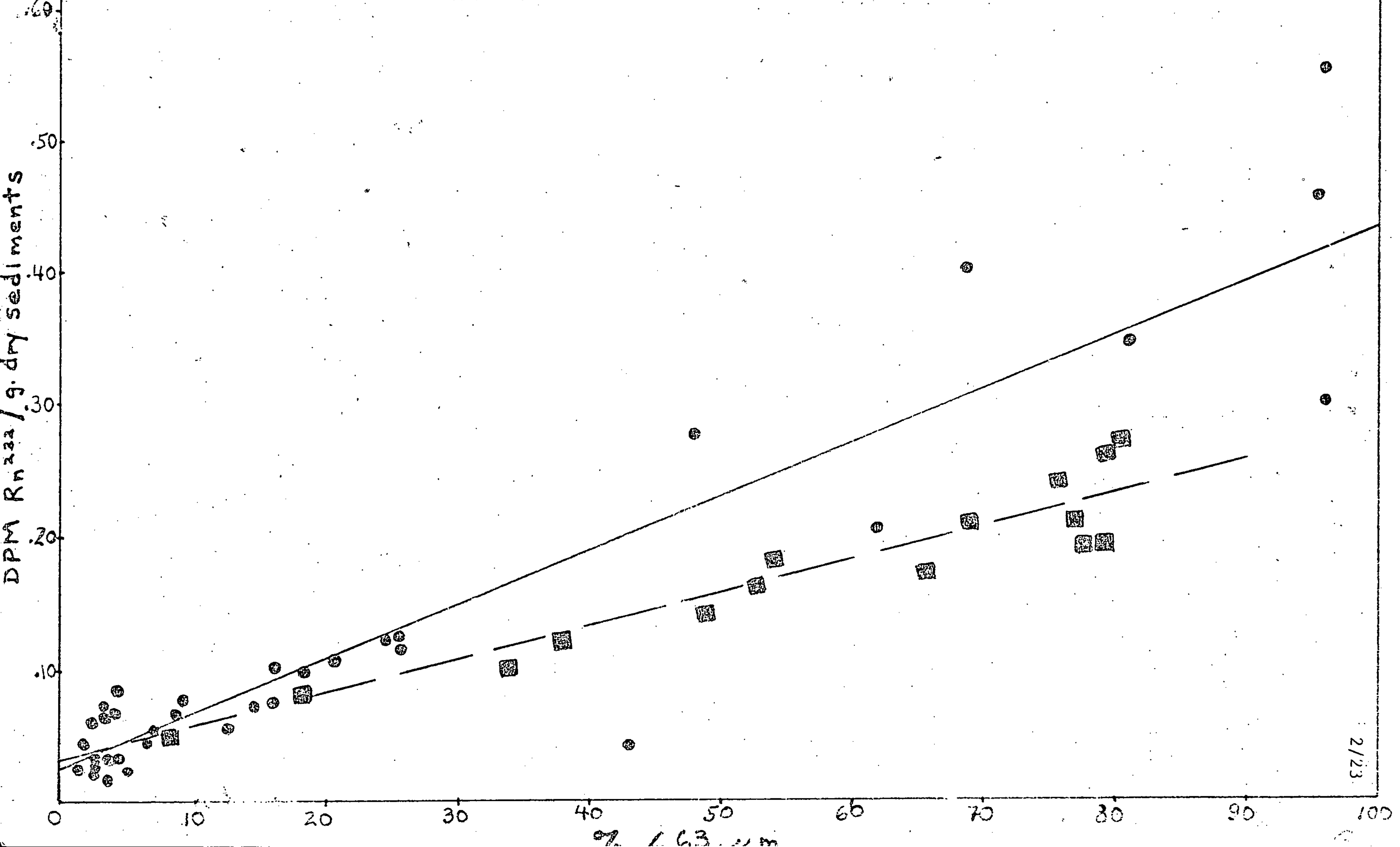
Figure 10

Potential radon production in bottom sediments as a function of grain size (% < 63 μm).



boundaries of the shelf-radon system beyond which certain assumptions do not apply. We thus have a substantial data base on which to begin to model shelf mixing processes.

2.4 References

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3.0 MIXING AND DISPERSAL OF SOLIDS AND TRACE METALS

3.1 General Statement

Certain pollutants of anthropogenic origin, which are related to the production or expenditure of energy, impinge on the marine environment of the New York Bight as species dissolved or carried in water, e.g. thermal pollution from power plants or, in part, carbon dioxide from the burning of fossil fuel. The dispersal of these species is by processes of advection and diffusion which operate on the water column and, at least by implication, have been considered in Section 2.0 above. A greater variety of real and potential energy-related pollutants exist as solids or are introduced to the New York Bight as dissolved species but become quickly adsorbed onto, incorporated or chemically transformed into solid species.

The chemical reactivity of fine particles and the biological incorporation of trace elements into fine particles is generally accepted as a truism. To understand man's impact on the waters of the adjacent continental shelf and in particular the effect of pollutants related to his production, transportation and utilization of various sources of energy, one must be concerned with the origin, dispersal and fate of suspended particulate matter. Suspended particles have a host of inter-related origins, both natural (biogenic, riverborne, eolian, resuspended sediments) and anthropogenic (huge quantities of dumped materials including sewage sludge, dredge spoils, cellar rubble, chemical wastes as well as air-borne fly ash from adjacent urban areas and from ship and air traffic across the Bight). This array of particulate matter includes species which are in themselves pollutants, those which carry (and are sources of) chemical and ratioactive pollutants, and those which act as sinks for these pollutants. The varied sources and roles of suspended particles makes a complex problem of understanding their origins, dispersal in the water column and removal to the sediments. The problem of resuspension from the sediments raises the level of complexity.

As described below, we approach the problem from several points of view and have realistic expectations of being able to make quantitative models of several aspects of the problem.

3.2 Suspended Particulates

3.2.1 Concentrations of Suspended Particulate Matter (Filtration and Gravimetric Analysis)

In addition to several tens of filters taken in 1973 and early 1974, we have data on suspended particulate concentrations throughout the New York Bight at three different seasons: autumn (October 1974, VEMA 32-01); summer (July 1975, CONRAD 19-01) and winter (January 1976, CONRAD 19-05). Data from the last cruise are not yet completely reduced. A qualitative analysis indicates that the January results are compatible with conclusions drawn from the first two cruises and incorporated in a paper by Biscaye and Olsen (in press; see Appendix IV). The principal conclusions are: (1) suspended particulate concentrations decrease seaward in both the surface and near-bottom waters. The isopleths of a given concentration, however, are displaced farther offshore in the near-bottom waters than in the surface waters (Figs. 1-3 Appendix IV); (2) Patches of anomalously high concentrations in near-bottom waters represent local resuspension of fine-grained sediment (Figs. 1, 2, 4 Appendix IV). The scale of displacement of these patches from their sources (up to tens of kilometers) suggests short residence times for most of the particles in the water column; (3) A zone exists near the bottom along the upper continental slope from about 1000 to 2000 m isobath in which suspended particulate (and excess radon) concentrations are anomalously low (Figs. 1, 2, 5, 6 Appendix IV). This apparently represents a zone of rapid horizontal mixing with open oceanic water; (4) A seasonal thermocline on the shelf sharply limits the vertical mixing of particles resuspended from the bottom.

These conclusions represent merely the first analytical cut of the data and much more remains to be done with data already in hand.

3.2.2 Distributions of Suspended Particulate Concentrations by Nephelometer (Light Scattering) Measurements

Nephelometer profiles were taken during the three seasonal Bight cruises (V 32-01, autumn 1974; RC 19-01, summer 1975; and RC 19-05, winter 1976). The vertical profiles were made using the standard Lamont-Thorndike photographic nephelometer (Thorndike, 1975). A 51 day time series of light-scattering measurements was made in the Hudson Canyon using a modification of this instrument. The data obtained are in various stages of reduction and analysis.

From the data already in hand, a partial picture of the complex nature of the light scattering on the Bight has begun to emerge. The picture largely substantiates the gross features derived from discrete sample concentration data (see Appendix IV) but the two sets of data need to be integrated and discrepancies between them resolved in several particulars.

3.2.2.1 Light-scattering Measurements in the Hudson Canyon

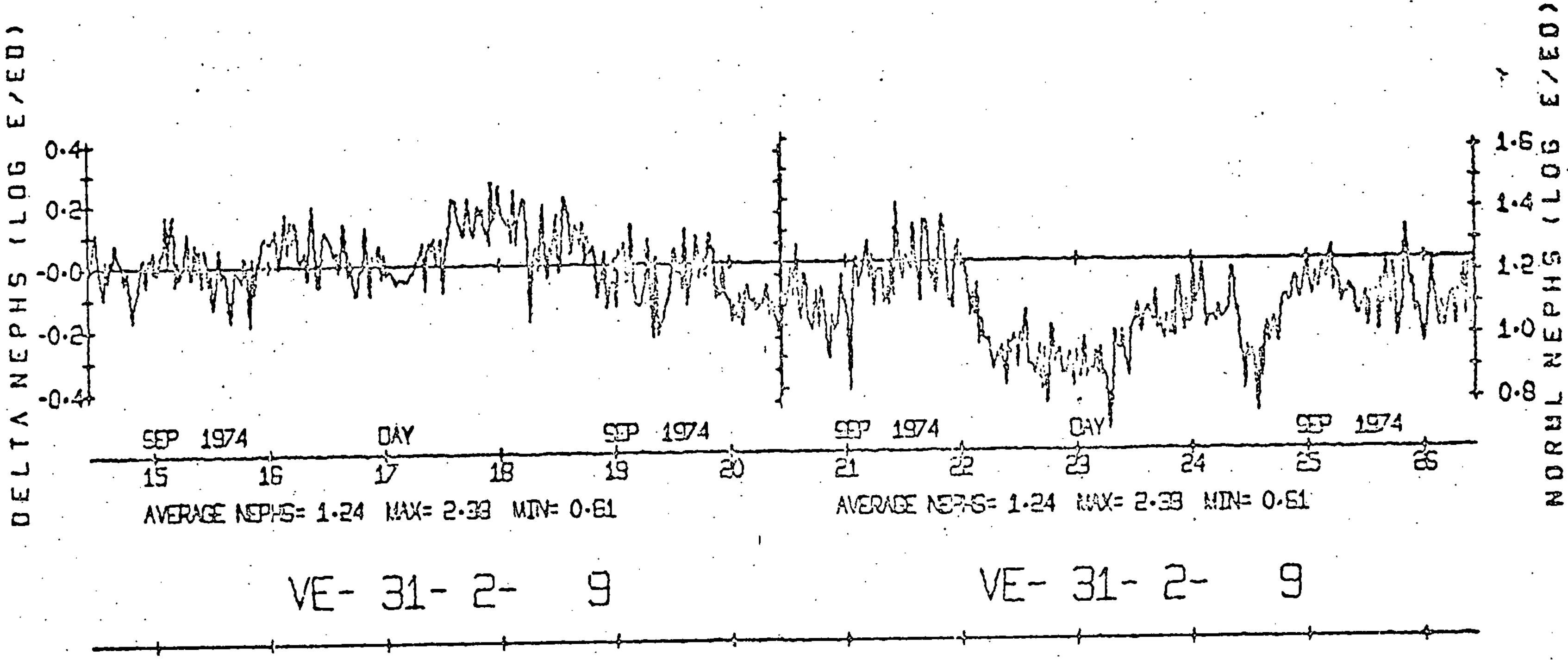
Two long-term measurements of Light-scattering have been made in the Hudson Canyon using a modified Thorndike nephelometer (Thorndike, 1975). Details of each mooring are tabulated below.

	Record 1	Record 2
Station Number	V-31-OBN-2	RC-18-OBN-2
Ship	VEMA	CONRAD
Cruise Leg	31-08 to 32-01	18-06 to 19-01
Latitude	39°29.8'N	39°29.5'N
Longitude	72°17.6'W	72°16.5'W
Water Depth	827 m	822 m
Height Above Bottom	9 m	15 m
Date Deployed	1027Z; 02 Sep 74	2236Z; 14 Jul 75
Date Recovered	1230Z; 25 Oct 74	0953Z; 01 Aug 75
Length of Usable Record	49 days	16 days
Recording Interval	30 minutes	15 minutes

Analysis of the data from these two records shows that the average level of light-scattering was $\log(E/E_D) = 1.24$ for the September-October record, where E is the exposure density of the scattered light and E_D is the exposure density of direct light detected through a neutral density attenuator in the nephelometer. This is equivalent to a suspended particulate concentration of $\sim 40\ \mu g\ l^{-1}$ if one applies the relationship derived experimentally in the deep sea by Biscaye and Eittreim (1974). The total range of light-scattering was from $\log(E/E_D) = 0.6$ ($8\ \mu g\ l^{-1}$) to 1.8 ($190\ \mu g\ l^{-1}$) (Fig. 11). Both long period and short-period oscillations in light scattering occur throughout both recording periods. Spectral analysis of both nephelometer records shows peaks occurring at the diurnal (O_1) tidal period, and lesser peaks at the semidiurnal (M_2) period. In the longer record (September-October 1974) (Fig. 12),

Figure 11

Section of ocean bottom nephelometer (OBN) record in the Hudson Canyon during September 1974. The data are plotted about the mean light scattering for the entire record (left hand scale). Absolute values are given in the right hand scale.



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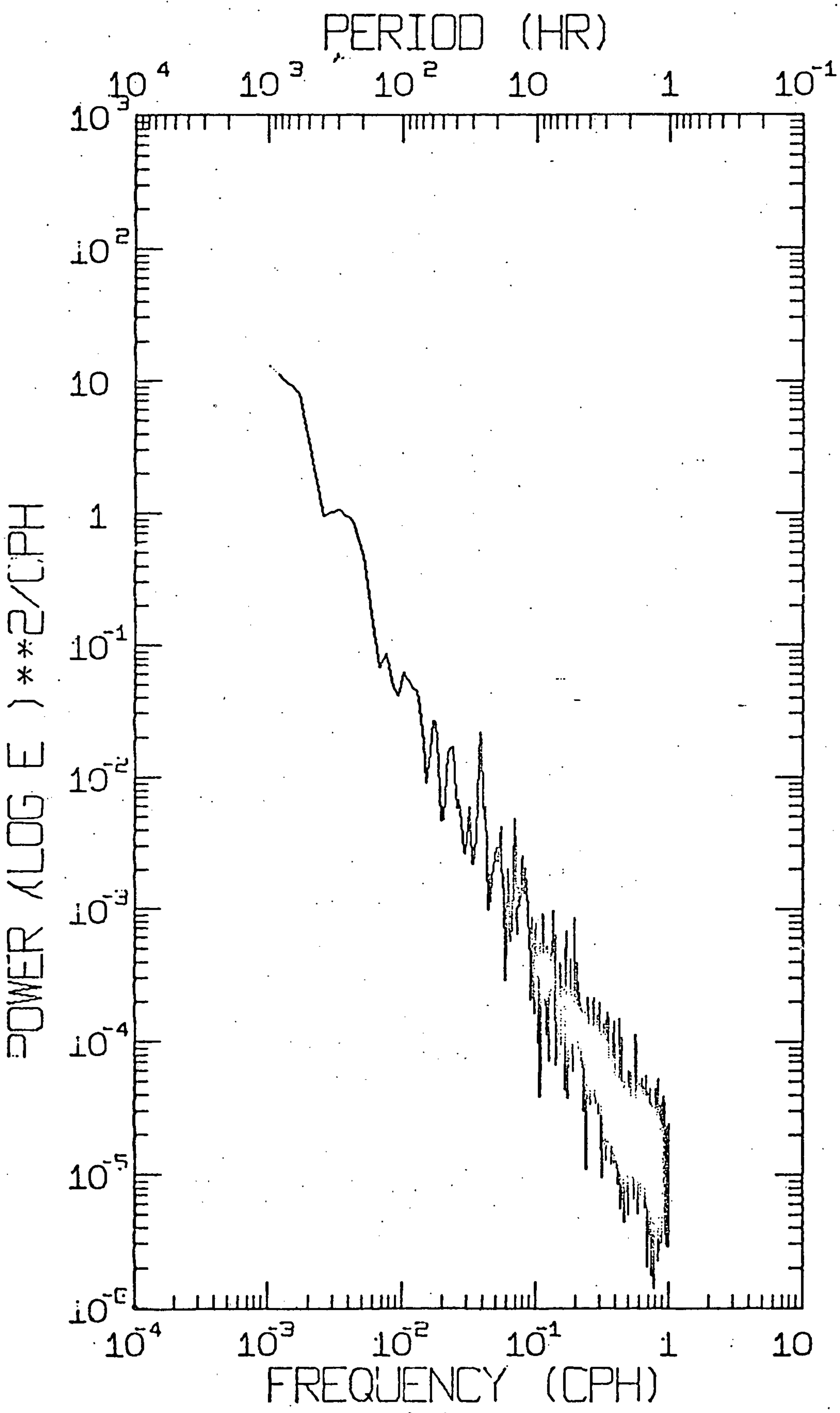

Figure 12

Power spectrum of light scattering in the Hudson Canyon during September and October 1974.

a slight peak at 200 hours occurs. When the data are passed through a 48-hour low-pass filter, several long-term fluctuations are revealed. However, the series is not long enough to resolve their period accurately. We feel that the revelation that light-scattering in the Hudson Canyon has a distinct tidal signal is a significant finding that will help in understanding the mechanisms controlling sediment transport in the Canyon and possibly the dispersal of particulate or particle-bound pollutants.

3.2.3 Composition of Suspended Particles

Knowledge of the concentrations and compositions of suspended particles is basic to a quantitative understanding of their role in geochemical cycles and of the processes of their dispersal in the Bight. Several publications present data on concentrations of suspended particles in waters of various locations on the east coast continental shelf although these consist of less dense sampling over a larger area of the shelf or equally dense sampling of a different shelf area. Few publications, however, present data on the composition of suspended particles and most of those which do report some type of bulk analysis of the material.

Particle characteristics reported here are based on morphology and chemical composition of discrete particles using combined scanning electron microscopy (SEM) and energy-dispersive x-ray fluorescence (EDXRF). EDXRF is a microanalytical technique in which the SEM electron beam is focused on an individual particle and the elemental composition (for elements of atomic number $Z \geq 9$) is determined from characteristic x-rays visually displayed as peaks on the energy spectrum in the x-ray analyzer. Although it is more difficult to quantify results from this technique, it has the advantage that one can directly observe inter-particle associations and associations between particle types and trace elements.

We group suspended particles in the New York Bight into two major categories: biogenic and non-biogenic. Of the biogenic fraction, skeletal debris is easiest to identify and is predominately siliceous, consisting primarily of diatoms with some silicoflagellates and a few radiolarian fragments. Calcareous skeletal debris (primarily coccolithophorids) become increasingly more abundant in the waters near and beyond the shelf break.

Non-skeletal biogenic debris (termed "organic") is much more complicated subdivision and includes a wide range of morphologies and elemental compositions.

Organic matter can originate from in situ biogenic productivity in surface waters, and consists of soft bodied plants and animals and their waste and decay products. Organic particles are also introduced by estuarine runoff or dumping of sewage sludges and dredged wastes. There appear to be regional differences in types of organic matter. Results based on this classification are given in Biscaye and Olsen (in press) which is included in this Report as Appendix IV.

3.2.4 Suspended Particulate Size Frequency Distributions

Beginning with the July 1975 cruise we began measuring suspended particulate size distributions in the New York Bight.

Particulate size data for representative areas in the New York Bight during January 1976 indicate the following: (1) Particles on the order of 1 to 4 μm in diameter completely dominate (by number) all areas and at all depths in the New York Bight; (2) Larger particles (10-60 μm) occur most often in surface waters and in near-shore waters, especially over coarse-grained bottom sediment; (3) Examination under scanning electron microscope (SEM) indicatest that plankton account for much of the 10-60 μm particles in the surface waters, whereas individual mineral grains and organic-clay aggregates comprise the larger particles in near-bottom waters; (4) Particles in the Hudson Canyon have a characteristic volume mode in the 7 to 12 μm diameter range and SEM examination indicates clay aggregates are responsible for this mode; (5) Particles southwest of the Hudson Canyon show a similar volume mode except in near surface waters where there is relatively more plankton debris; (6) Particles north of the Hudson Canyon do not show the 7-12 μm volume mode, perhaps indicating a southern overflow of Canyon water.

3.3 Radioactive Tracers

3.3.1 Anthropogenic Nuclides as Tracers of Fine-Grained Sediment Transport

We have begun to exploit the presence of anthropogenic radionculides in particulate phases in the Hudson Estuary and adjacent coastal waters to describe transport and accumulation patterns of fine-grained particulates.

Our primary effort in exploiting Cs^{137}, Cs^{134}, Co^{60} and $Pu^{239,240}$ as tracers of fine particles up to now has been to map the distribution of these nuclides in sediments. We have collected a substantial number of core samples (both gravity and piston cores) and surface grab samples. We have also begun to collect large samples of suspended particles (up to 10-40 grams in the case of the Hudson Estuary) by using a continuous-flow centrifuge, as well as settling tanks and a large filtering system.

Analysis of over 50 cores from the Hudson (work done under contract E-2529), indicate that much of this reactor-tagged sediment is accumulating in the inner harbor area adjacent to New York City.

Preliminary analyses for Cs^{137}, Co^{60} and Cs^{134} in grab samples taken from the Bight indicate the presence of fallout Cs^{137} in nearly all fine particulate samples but only a few samples contain Co^{60} and Cs^{134}. Samples from the Bight Apex contain relatively high concentrations of Cs^{137} and detectable levels of Co^{60} (dump 2) or Cs^{134} (SG-150).

To obtain information on the removal, transport and accumulation of anthropogenic radionuclides in the coastal marine environment, we have also begun a study of Barnegat Bay.

A preliminary survey of the area has been completed and grab samples have been collected in Oyster Creek, Barnegat Bay and on the shelf near the Barnegat Bay inlet.

Both samples from Oyster Creek (Stations 9 and 10) contain anomalously high Co^{60} concentrations (approximately 10-30 times the highest value observed in the Hudson Estuary sediments).

3.3.2 Anthropogenic Tracers in the Water Column of the New York Bight: Plutonium

$Pu^{239,240}$ concentration is high at stations beyond the shelf break and is low at stations inside the break. In contrast, [Th^{228}] are quite uniform at all stations probably indicating that plutonium is more reactive than thorium with regard to particulate uptake in shelf water. The implication of our present data is that the continental shelf sediments serve as a sink for the fallout plutonium which has been deposited both on the continents and open oceans.

3.3.3 Th^{228} as a Naturally-Occurring Tracer of the Fate of Heavy Metals

Th^{228} data from two cruises (VEMA 32-01 and CONRAD 19-01) indicate that the Th^{228} concentratio of surface water around the coastal areas decreases toward the shore but it increases drastically within the inner shelf area (∿ 20 km from the coast) due partly to: (1) the high production rate of Th^{228} by Ra^{228} there, and partly to (2) the high concentration of suspended particulate matter which contribute significant Th^{228} as well as Th^{232}.

The continuously decreasing trend of the Th^{228}/Ra^{228} activity ratio toward the shore even within the inner shelf (Fig. 13) indicates that the area of the highest Th^{228} uptake by suspended particulates and living organisms (mainly phytoplankton) is located within the inner shelf area.

The model fitting of seasonal variation of Th^{228} concentration in surface water at the Bight Apex shows that in the winter season the particulate uptake of Th^{228} by absorption is the dominant term, but from March to September, the biological uptake of Th^{228} becomes important. The radioactive decay of Th^{228} is a minor term by comparison.

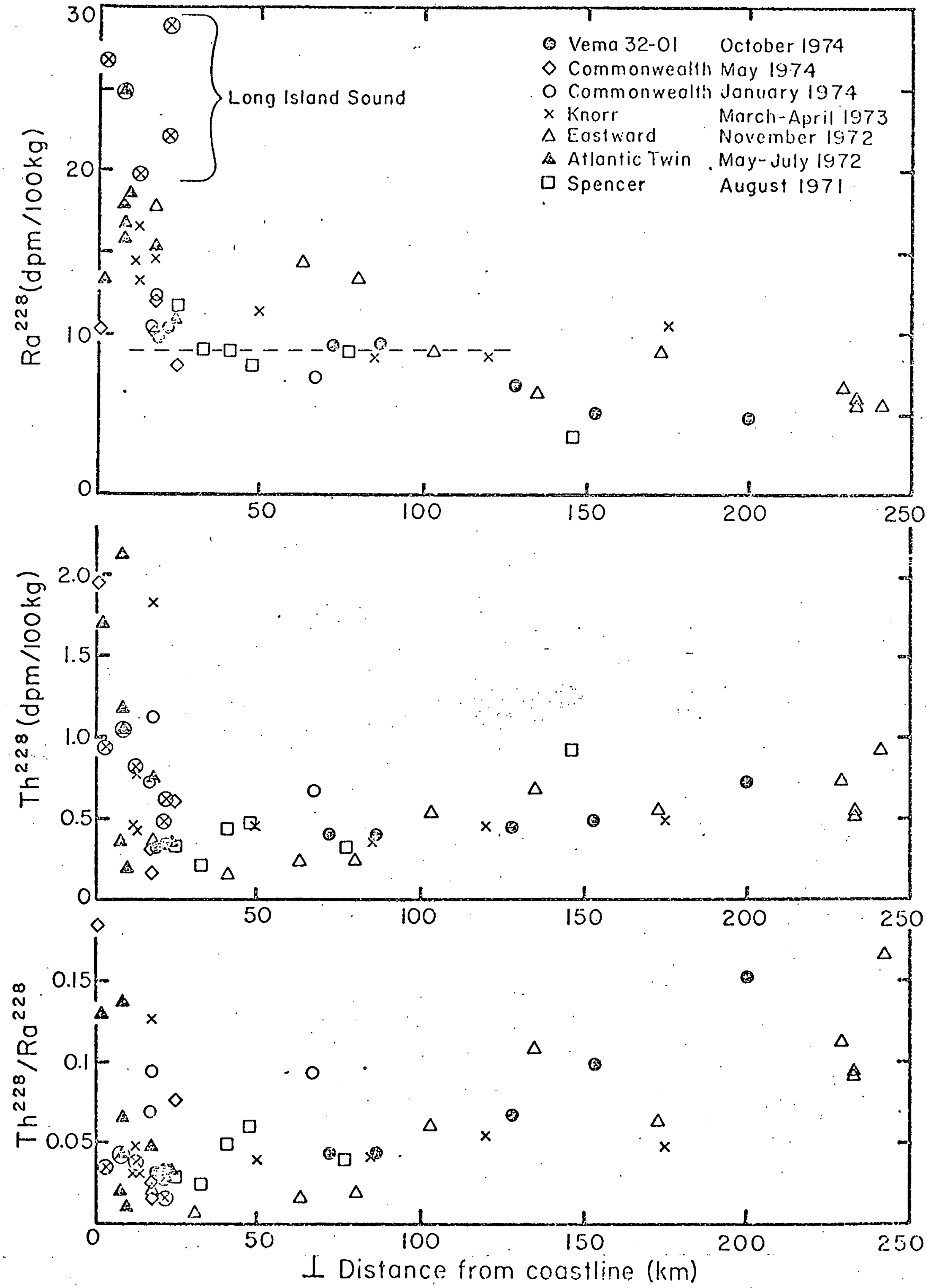

Figure 13

Summary of Ra^{228}-Th^{228} data from various cruises (1971-1974) as a function of the nearest distance from coastline.

3.4 References

Biscaye, P.E. and S.L. Eittreim, 1974. Variations in benthic boundary layer phenomena: nepheloid layer in the North American Basin. In: R.J. Gibbs (ed.), Suspended Solids in Water, Plenum Publ. Co., New York, pp.227-260.

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4.0 MIXING OF SPECIES ACROSS, WITHIN AND OUT OF SEDIMENTS

4.1 General Statement

The fate of suspended particulate matter and the non-dissolved pollutant species associated with them is ultimately deposition in the sediments. This is true whether deposition is within the Bight area of concern to us, whether the particles are carried in the water column to another part of the continental shelf and deposited, or whether export is directly seaward and deposition is in the deep sea. Sediments are however, only ultimately, a sink for particles and associated pollutants because, until buried below the zone of sediment stirring, sediments are susceptible to resuspension. Even after burial, chemical changes in the pore water environment can result in dissoltuion, cation exchange or some other form of remobilization of pollutant species and their diffusion back into the water column.

Consideration of the sediments as an active part of the pollutal-dispersal system is thus necessary.

During the 1975/1976 funding period work progresses on the B.O.M. (Bottom Ocean Monitor) instrument. Geochemical aspects of the processes that occur within the upper sediment column or across the sediment-water interface are described in detail in the accompanying proposal.

4.2 Bottom Ocean Monitor (B.O.M.)

The B.O.M. was conceived as a platform mounted on the ocean bottom on which could be mounted a number of instruments for the long-term observation and measurement of phenomena at or near the sediment-water interface, i.e., in the benthic boundary layer.

During the present period, two complete B.O.M. instruments were fabricated consisting of:

- Time Lapse Bottom Camera (capable of 4 months operation, 12 frames per day).
- Long Term Photographic Nephelometer (capable of 4 months operation with 12 observations per day).
- Current Meter (inclinometer-type with 1 hour sample interval for 4 months operation).

Testing was accomplished in shallow water during the summer of 1975 in Gardiner's Bay, Long Island. These developments were in anticipation of use of the B.O.M. instruments during the winter period with the cooperation of the NOAA/MESA group. Unfortunately, the field operations tentatively planned for the winter period with the NOAA group could not be effected. Rough weather and changes in the budget and the mission of the NOAA project precluded our participation during the winter period. In February 1976 one of the B.O.M. units was made ready to participate in the inter-institutional current meter test program planned for February-March 1976 in the waters south of Shinnecock Inlet, Long Island. Our equipment and personnel went aboard R/V WARFIELD (operated by Chesapeake Bay Institute) on 2 February 1976. Due to rough weather on 3 February, during the attempted launch damage occurred to the B.O.M. and part of the equipment was left on the sea floor near the current meter array. Following the accident, plans were made for diver recovery in late March utilizing an acoustic marker which had been attached to the portion of the instrument that was inadvertently left on the ocean floor. On 15 March workers from Brookhaven Labs, CBI and Lamont attempted to make recovery of the B.O.M. instrumentation. However, the pinger which had been attached to the equipment did not appear to be operating and no contact was possible with the missing equipment. At the present time we plan to utilize a side-scan sonar to search the area around one of the marker buoys which remains from the original array. Results of this search should be available early in April. The side-scan sonar equipment has been chartered by Brookhaven Laboratories in order to attempt recovery of their SPAR-type current meter array which failed and apparently sank late in March.

Based upon the experience during the recent launching attempt, we have constructed new and stronger fittings for the tripod assembly which should prevent breakage due to rough handling in future deployments of the B.O.M. instruments.

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5.0 PAPERS ACKNOWLEDGING ERDA GRANT E(11-1)-2185 SUPPORT

5.1. Papers published and in press

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Rooth, C. and P. Biscaye (in prep.). An estimate of deep-sea horizontal eddy diffusivity from excess radon data.

5.3 Talks given

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CRUISE REPORT

CONRAD Cruise 19 Leg 1

Piermont to New York (Brooklyn), 19 July to 4 August 1975

OBJECTIVES

The objectives of this leg were a combined geochemical-physical oceanographic study of the hydrography, mixing and sediment dispersal processes on the Continental Shelf and Upper Continental Slope in the New York Bight. Having done a similar study in October 1974 on VEMA 32-01, the objective was to compare the results of the CONRAD analyses, done under summer hydrographic conditions, with those of the autumn regime.

The work is funded by the Energy Research Development Administration (ERDA) under contract AT (11-1) 2185 into which the former contract AT (11-1) 3132 has been combined. ERDA's objectives in funding this work is to understand the disposal paths and the rates at which the mixing and exchange of water in the Bight takes place, in which the effects of present and potential anthropogenic influences - chemical pollutants, solid garbage, thermal plumes, oil spills and leaks from drilling operations,etc. - are dispersed and diluted.

The track was laid out to approximate but not duplicate the one made on VEMA, and consisted roughly of two transverse sections across the shelf from 25 to 1000 fathoms water depth; roughly three longitudinal (parallel to isobath) sections between the transverse sections; and a number of stations in both the Hudson Shelf Channel and Hudson Canyon.

ACCOMPLISHMENTS

During the sixteen days at sea we made seventy-two stations at which one or more measuring instruments or sampling devices were lowered into the water. Several stations were occupied more than once during the leg to determine variability on that time scale, and a number of stations were reoccupations of stations made on VEMA 32-01.

GEOCHEMICAL PROGRAM

The geochemical program was divided roughly into two aspects:

1. Work involving particulate matter both as suspended particulates and as bottom sediments, and
2. collection of samples for analysis (on board and at Lamont-Doherty Geological Observatory) of naturally occurring radioactive species to measure mixing.

We accomplished the following: 1 six inch diameter Sanders Core (S6C-1). This coring device is a scale-up of one used last October on VEMA and retains the essential feature that water above the sediment - water interface is retained intact in the upper portion of the core liner. The purpose of these cores is to recover in as undisturbed a condition as possible a sample of the uppermost surface sediment and the water overlying it for diffusion studies. the major problem with this coring rig at this stage in its evolution was that, because its fingers deeply scored the edges of the core as it penetrated, the core catcher had to be omitted. This caused involuntary extrusion of the core and its loss into the water as soon as the bottom of the four foot long core barrel was raised above the air-sea interface. After some experimentation a collar and flap was designed to slide down the core tube and rotate across the cutting edge to close off the core. This operation however, had to be done manually which meant that someone had to go into the water to release the collar and flap, slide it down the core barrel and close the flap. With some difficulty this operation is possible during July but must clearly be modified for the next cruise in January.

One core was successfully taken using this rig and, in an unwise concession to the difficulties of extruding such a core in a vertical position, the cutting head was omitted on the second try and the core liner and valve were sucked out of the core barrel by the friction of pull-out from the sediment and were lost.

8 three inch diameter Sanders Cores (S3C-1 through S3C-8). The same principle as that described above except that no problems of involuntary extrusion were encountered. A semi-circular metal flange however, had to be welded to the outside of the core barrel to reduce the possibility of overpenetration. This happened twice in very soft sediment and drove sediment up through the valve at the top of the liner.

74 Shipek Grab Samples (numbers SG150 through SG223). These are surface sediment grabs.

65 30 liter Niskin bottle casts (RN 50 through RN 114), usually consisting of eight bottles on the hydrowire. The following analyses were done on these samples: salinity, dissolved oxygen (top and bottom bottles in each cast), excess radon, turbidity (Hach turbidimeter), size frequency distribution of particulates by Coulter Counter, and water was filtered on to pre-weighed Nuclepore filters for gravimetric analysis of particulate concentrations. The filters will also be analyzed for mineralogy by X-ray diffraction and by combined scanning electron microscope - energy dispersion X-ray fluorescent for particulate compositions.

1 station (F-14) at which only one 30 liter Niskin was taken for the particulates work and not for radon.

63 stations at which the major nutrients silicate, nitrate and phosphate and dissolved oxygen were analyzed on all water samples taken as calibration for the STD. A total of 664 analyses of each of the three nutrients and 1030 analyses of dissolved oxygen were made.

62 stations at which 122 large volume (200 gallon) samples of water were taken from the surface down to 55 meter depth by lowering a submersible pump. These samples were numbered P-41 through P-162 in the log. These samples were chemically treated for the removal of radium and thorium-228 which will be analyzed in the laboratory. The water from 34 of these samples was filtered for discrimination between the concentration of these isotopes in the dissolved versus the particulate phases.

35 stations at which at least one sample of water was taken from the 1.7 l. STD calibration bottles for analysis of oxygen isotope ratios. 130 such samples were taken.

24 stations at which at least one sample of water was taken from the 1.7 l. STD calibration bottles for analysis of dissolved methane. 59 such samples were taken.

PHYSICAL OCEANOGRAPHY PROGRAM

The physical oceanography program consisted of the following measurements:

1. Continuous surface-to-bottom STD program: salinity and temperature profiles using a PLessey model 9040 STD sensor.

2. Water sampling program:

1.7 l. sea water samples collected by a General Oceanics

Rosette sampler in conjunction with the STD. These samples were routinely analyzed for salinity using a guildline Instruments model 8400 salinometer. The salinity samples were used to define maxima and minima indicated by the STD and to calibrate the STD in-situ. Dissolved oxygen analyses were run on board from all Rosette samples by the Geochemistry group using the Carpenter method and nutrient determinations were made on all samples (see Geochemistry Section). Hence the sampling interval chosen for the twelve bottles on the Rosette was determined by the requirements of adequately describing the O_2 and nutrient chemistry distribution, calibrating the STD and verifying inversions found in the water column.

3. Thermometry program; Six of the twelve Rosette bottles had frames for holding reversing thermometers. In conjunction with the salinity samples, the thermometry provided us with back-up hydrographic data that would be usable in lieu of the STD data should a major STD malfunction occur. Additionally the protected and unprotected thermometer data will be used to calibrate the STD temperature and depth sensors.

4. Surface temperature and salinity program: Continuous underway records of sea-surface temperature, air temperature and relative humidity were made throughout the cruise and underway surface samples were collected at 2 N.M. intervals and analyzed for salinity on board.

5. Bottom photography/nephelometry program: Two LDGO nephelometers were used - one that was attached to the STD wire just above the STD sensor, and the other in a normal camera/nephelometer con-

figuration. Due to the shallow water throughout much of the area, shallow nephelometry had to be restricted to the nighttime hours.

6. Long-term current measurements and nephelometry; A current meter/nephelometer package which was deployed on the previous leg of CONRAD in the Hudson Canyon was recovered successfully during the present leg. Analysis of the data is now underway at Lamont-Doherty Geological Observatory.

The following table summarizes the number of stations and samples collected for the physical oceanography program during the cruise.

Program	Station Numbers	Number of Stations, Samples
STD stations	381-444	64
Salinity samples	-	1180
Surface salinity samples		138
Nephelometer stations	1 - 38	38
camera stations	1 - 14	14
		1030

PERSONNEL

The following personnel comprised the scientific party on RC 19-01:

Geochemistry

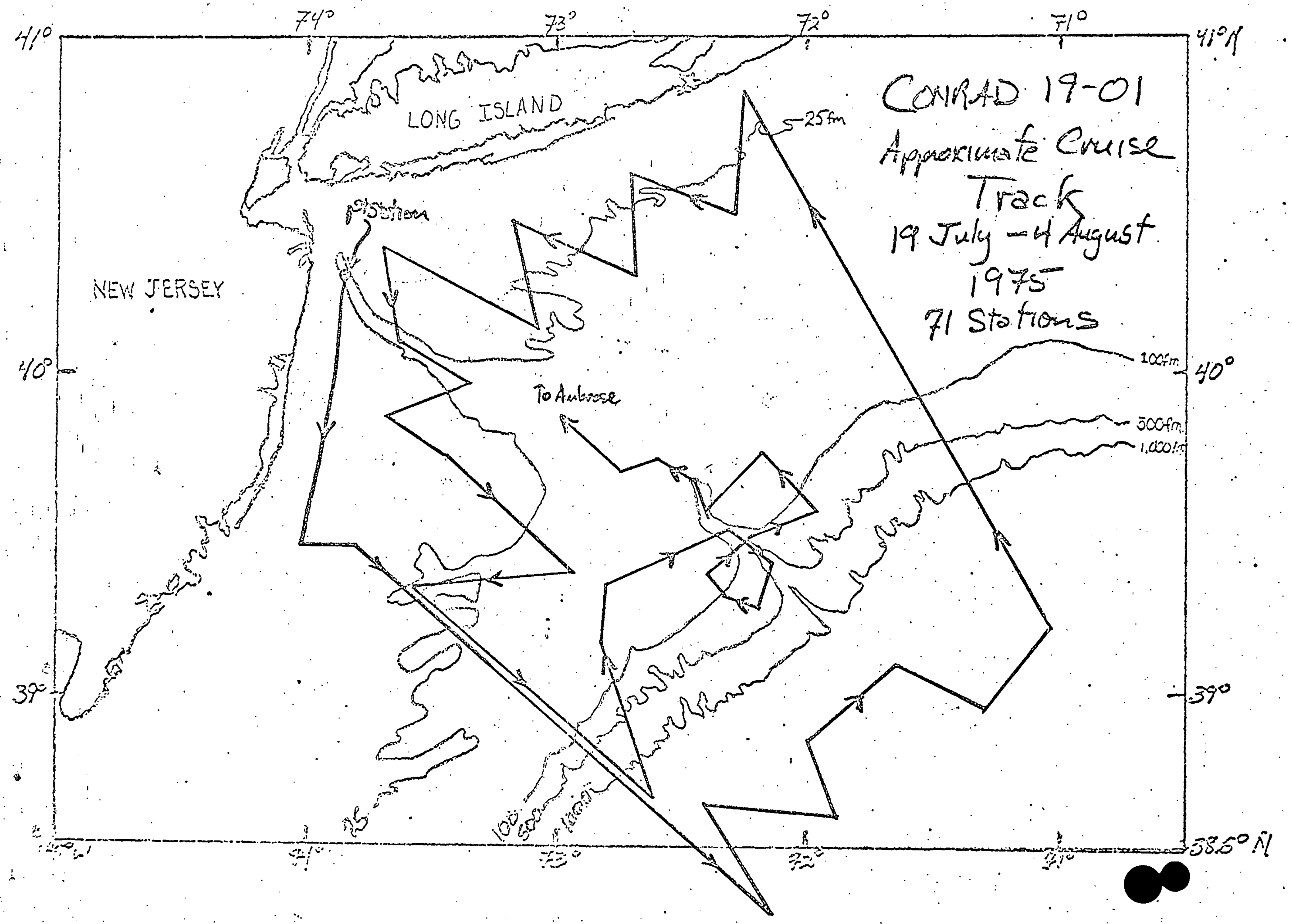
Pierre Biscaye (Co-Chief Scientist)
Bruce Deck
Herb Feely
Marty Friedmann
Adele Hanley
Cathy Haward
David Hadko
Carolyn Kent
Bruce Markwalter
Guy Mathieu
Curt Olsen
Mike Prokopchak
Rob Togweiller
Tom Torgerson

Physical Oceanography

Anthony Amos (Co-Chief Scientist)
Ted Baker
Kathy Cooke
Scott Daubin
Gene Molinelli
Jan Szelag

Other

Al Hagan (Core Bos'n)
Matt Bye (Core Crew)
Jim Williar (ET)


CONRAD 19-01
Approximate Cruise
Track
19 July – 4 August
1975
71 Stations
LONG ISLAND
NEW JERSEY
To Ambrose
25fm
100fm
500fm
1,000fm
74°
73°
72°
71°
41°
41°N
40°
39°
38.5°N

PRELIMINARY CRUISE REPORT

R/V CONRAD CRUISE 19 LEG 5

NEW YORK - NEW YORK

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Geochemistry

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- Pump Stations
- Particulates
  - *Turbidometer, Filter and Coulter Counter*
  - *Nephelometer/Camera*
- Sediments

Biological Oceanography

- Plankton
- Benthos

REFERENCES

PRELIMINARY CRUISE REPORT

R/V CONRAD CRUISE 19 LEG 5

NEW YORK - NEW YORK

CRUISE TRACK

CONRAD 19 leg 5 departed Brooklyn Navy Yard at 1430 EST, 4 January 1974 and returned to Brooklyn Navy Yard at 0919 EST, 21 January 1976. This cruise was the third in a series of four proposed seasonal investigations into the physical oceanography and geochemistry of the New York Bight region supported by ERDA contract AT 2185. The cruise track (Figure 1) consisted of transects normal to the isobaths, from the inner continental shelf, across the shelf-break and the slope to the 1500 fm. line. Another transect followed the axis of the Hudson Submarine Channel "Delta" area and Canyon.

Many of the stations along these transects were reoccupations of stations run on the previous two cruises (VEMA 32 leg 1: October 1974 and CONRAD 19 leg 1: July and August 1975). An additional line of stations was run along the shelf from west-to-east to examine the region of sedimentary fines (the "mud-hole") located south of Block I. An unscheduled stop was made at the University of Rhode Island's Narragansett marine facility to pick up a data logging system for the STD to replace our own system which was delayed in transit between Argentina and Lamont.

STATION WORK

During the 17-day leg, a total of 100 ship's stations were occupied on which 382 separate over-the-side operations were made. The station breakdown is given in Table 1 along with totals from the two previous cruises.

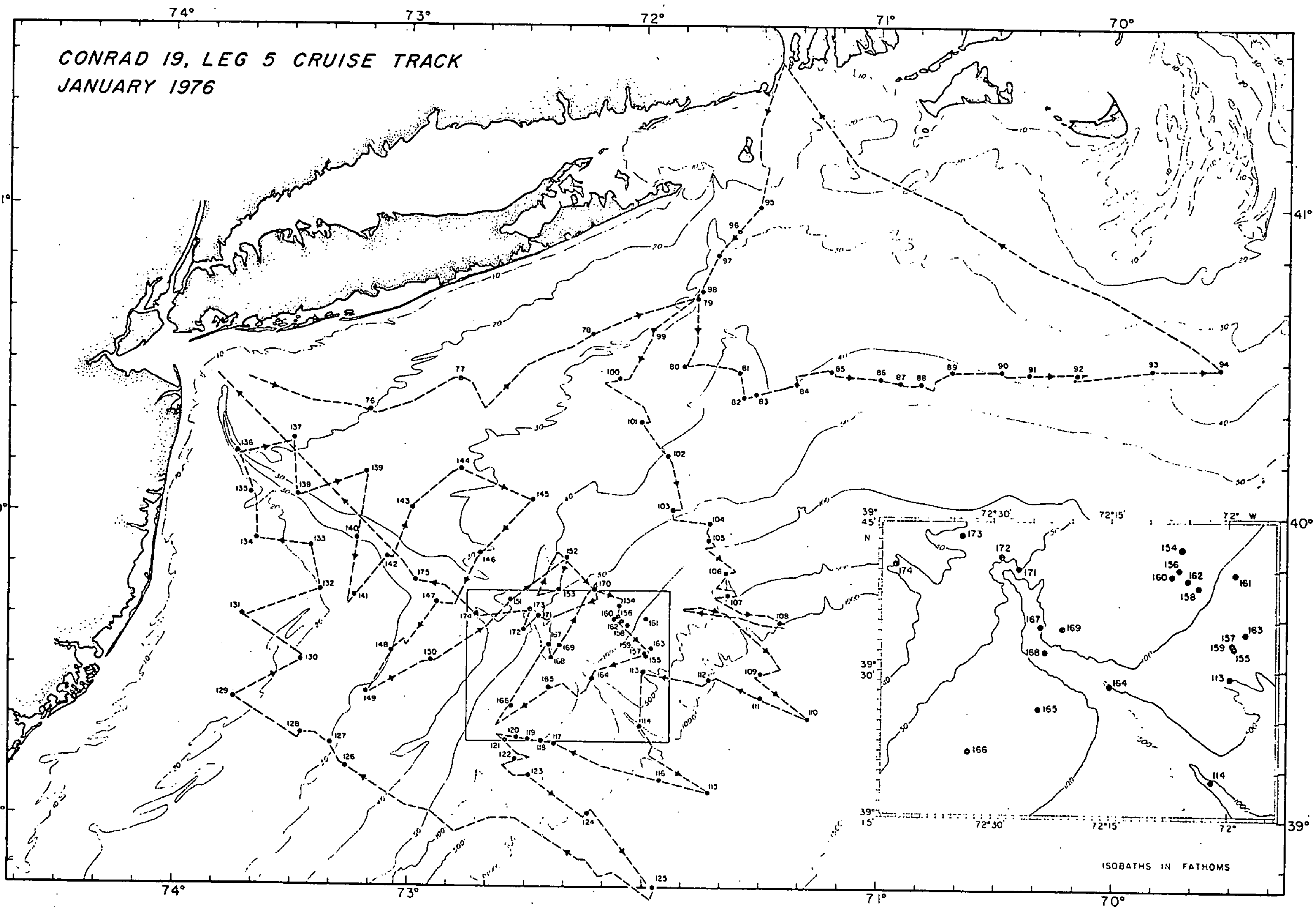
CONRAD 19, LEG 5 CRUISE TRACK
JANUARY 1976
74°
73°
72°
71°
70°
41°
40°
39°
ISOBATHS IN FATHOMS

FIGURE 1

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY
of COLUMBIA UNIVERSITY
Palisades, N. Y. 10964

STATION SUMMARY

STATION TYPE	VEMA 32 Leg 1 16 Oct - 31 Oct, 1974	CONRAD 19 Leg 1 19 Jul - 4 Aug, 1975	CONRAD 19 Leg 5 4 Jan - 21 Jan, 1976	Totals
STD	58	60	81	199
HYDRO		4		4
RADON	35	65	81	181
FILTER	12	2		14
PUMP	60	121	78	259
NEPHELOMETER	13	38	32	83
CAMERA	9	14	3	26
SHIPEK GRAB	41	73	80	194
CORE	2	1	5	8
GRAVITY CORE			9	9
3" SANDERS CORE		8		8
6" SANDERS CORE		2		2
PLANKTON TOW	—	—	13	13
TOTALS	230	388	382	1000

TABLE 1

The totals for the various samples collected on each station are given in Table 2 with the previous two cruise totals included for comparison.

The general upward progression in numbers of stations taken and samples collected are indicative of the increasing efficiency of the shipboard team carrying out these New York Bight cruises. Our work output could have been even higher had we not had some long periods when bad weather prevented over-the-side activities.

UNDERWAY MEASUREMENTS

Continuous underway sea surface temperature, air temperature and dew-point records were kept. The standard 3.5 KHz and 12 KHz PDR records were maintained throughout but no gravity, seismic or magnetometer data were collected. For part of the cruise the 12-channel course, speed recorder was kept running to aid in the navigation but this malfunctioned and its use was discontinued. Navigation was accomplished using the Magnavox satellite system and Loran-C provided good back-up fixes during this near-coastal cruise.

PROGRAM DESCRIPTIONS

Physical Oceanography

STD

Two STD underwater sensors were used: (1) the original Lamont (Bissett-Berman, now Plessey) Model 9006 fish (first used in July 1964), modified to accept a 1500 m depth sensor and to mate with a General Oceanics Rosette sampler; (2) a Plessey Model 9040

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY
of COLUMBIA UNIVERSITY
Palisades, N. Y. 10964

SAMPLE SUMMARY

SAMPLE SUMMARY	VEMA 32 Leg 1 16 Oct - 31 Oct, 1974	CONRAD 19 Leg 1 19 Jul - 4 Aug, 1975	CONRAD 19 Leg 5 4 Jan - 21 Jan, 1976	Totals
SALINITY	778	1333	1129	3240
OXYGEN	473	1016	472	1961
PHOSPHATE	82	584	472	1138
SILICATE	82	584	472	1138
NITRATE	82	-	-	82
NITRITE	82	-	-	82
AMMONIA	82	-	-	82
RADON	255	490	627	1372
PARTICULATES	300	438	551	1289
COULTER COUNTER	-	500	600	1100
TOTALS	2216	4945	4323	11484

TABLE 2

fish (first used in July 1967) with a 7000 m. depth sensor that we have used in most of our deep ocean work at Lamont. The data was recorded on an X_1, X_2, Y recorder (also 1964 vintage) and after January 7 on URI's data logging system that consists of a digitizer, a NOVA 1200 central processing unit with LINC tape drives, a teletype, a 9-track Kennedy digital tape recorder and a Houston Instruments plotter.

At each station, the STD/Rosette sampler was lowered to within a meter or two above the ocean floor (using a pinger) at a rate that varied from 10 fm/min in the high-gradient upper water layers to 40 fm/min below the thermocline. From five to twelve Rosette bottles (alternate bottles having three reversing thermometers attached) were tripped during the descent (downtrace) of the STD. These samples had two main uses (1) to calibrate the STD sensors, (2) to provide adequate coverage of the water-column for analysis of dissolved oxygen and the nutrients, silicate and phosphate. A full description of the STD techniques used is given in Amos (1973). A total of 81 successful stations were taken. Of these, 32 will have to be digitized from the analog records. The rest are available on digital magnetic tape from the URI system. It was intended to use the shallow STD (to increase depth resolution) on all shelf stations but a malfunction of the depth sensor forced us to use the 7000 m. sensor throughout most of the cruise. For some stations without digital recording, depth resolution will be very poor.

A time series of STD/radon measurements was made over a 25-hour period in an attempt to see if internal surfs (Gordon et al, 1975) are important mechanisms in the exchange of waters over the shelf break. STD lowerings followed by radon casts were made alternately at the 70 fm. isobath on the outer shelf and the 300 fm isobath on the slope. Five stations of each kind were made at each location.

Time-Series Station

To enhance the quality of the time-series STD data lowering and raising speed of the instrument was maintained at exactly 10 fm/min throughout the entire water column. Preliminary analysis of the vertical temperature and salinity profiles shows that large amplitude internal waves are present although their period is not known at this writing. In the shallow station the depth of the pycnocline varied from 40 m to 75 m over 25 hours. The pycnocline was deepest at the first station, then became progressively shallower for the next two stations. The fourth station in the series showed a striking two-layered pycnocline with steep gradients at 30 m and 60 m. The final shallow station's pycnocline was intermediate between the two-layered structure of the fourth profile and the steep pycnocline of the first profile. The interpretation of these results will have to wait until a complete analyses of the data is completed.

At the deep station the profiles were of two types. The first two stations had a 65 m mixed layer with a 15 m. pycnocline and the last three stations were more typical of the slope-water regime with a 120 m mixed layer and a very weak pycnocline. This may have been due to the shifting of the shelf-break front during the 25 hour study or, as positioning of the ship was difficult in the weather conditions encountered, some spatial changes may be responsible for the apparent change with time.

Preliminary Results

Generally the STD's behaved well, with no noise, spiking, shifting of output or large offset problems (Amos, 1973) occurring. Our STD equipment is however getting old (probably the oldest surviving equipment of this type in the oceanographic community) and newer, state-of-the-art CTD equipment is now available that greatly improves the problems associated with mismatched time constants, lowering rates and ships motion that contribute to salinity errors. While some coastal oceanographers feel that great accuracy is not essential in regions where large time-dependent changes occur, we feel that it is paramount to maintain as high quality hydrographic data as possible to fully understand the dynamics of shelf processes. The addition of a computer/plotter system enabled us to examine on a variety of scales, the water structure immediately after each station, allowing judgements to be made on the location of the next station, and an understanding of the hydrography just not possible with our older system.

The January conditions on the shelf were surprisingly variable surface-to-bottom, and except on the inner shelf, thorough mixing of the shelf waters had not yet occurred. The stratification was generally two-layered: colder, fresh surface water separated from warmer, saltier bottom water by a strong thermocline and halocline. As the temperature and salinity increases were mutually offsetting, density-wise, the resultant pycnocline was not as strong as at other seasons. Some large density inversion were noted that may be real or may be eliminated after the data has undergone correction for the time-lag errors. Surface temperatures varied from 6°C on the inner shelf to 14°C over the slope. A thermal front was located shoreward of the shelf break. The mixed layer varied from 30 m on the inner shelf to 70 m on the outer shelf and 150 m in the slope water. Bottom temperature on the shelf ranged from 6°C (near Bight apex) to 13°C. A large intrusion of warm, saltier water was found over much of the centered Eastern Shelf penetrating as far as the Block channel. In deeper water on the outer shelf and shelf-break a temperature maximum of approximately 15°C occurred at approximately 100 m. In the slope water, this maximum disappeared.

Salinity mirrored temperature over most of the area: low values of <32% at the surface were only found in the eastern part of the inner shelf while the 35.0°/∘∘ isohaline occurring well to the shoreward side of the shelf break. An isolated lens of >34.0°/∘∘ water was centered over the Hudson Canyon head. Bottom salinity ranged from 32°/∘∘ on the inner shelf but the 33°/∘∘ isohaline was much closer to the shore on the eastern shelf corresponding to the high bottom temperatures found there. The salinity maximum of 35.6°/∘∘ impinged on the bottom shoreward of the shelf break up into the Hudson canyon.

Rosette Water Sampling Program

Salinity

A total of 1200 salinity samples were run on a Guildline Autosal salinometer. Salinities were run on all Rosette samples and on all 30 liter Radon samples collected to provide information on possible pre-tripping or leaky bottles. The salinometer functioned very well during the cruise, exhibiting an extremely low drift rate. Two pressure pumps malfunctioned and had to be repaired. The sample holding table remains a weak point in the design of this instrument.

Dissolved Oxygen and Nutrients

Dissolved oxygen, silicate, and phosphate were analysed for each of the rosette bottles tripped on the STD cast. The sample for oxygen was drawn by overflow immediately into 300 ml BOD bottles after recovery of the STD. The samples for nutrients were drawn following this into 125 ml plastic bottles. The oxygen samples were processed by the modified Winkler procedure as described in "The Marine Technicians Handbook" with the following modifications: 1.5 ml of each of the pickling reagents were used for the 300 ml size bottles and the concentrations of the standard and thiosulfate solutions were doubled. Standards were run in duplicate or until .5% agreement at least twice daily. The shelf samples in the mixed zone were found to be nearly uniform and near saturation values of dissolved oxygen. A mid-depth oxygen minimum was observed as in previous cruises as was the high oxygen water beneath this.

Nutrient samples were allowed to warm in the plastic bottles for between 1/2 to 4 hours before analysis was made. The procedures used were those of Strickland and Parsons (1968) for molybdate reactive Silicate and Phosphate. Operating equipment and procedures were previously tested on the CONRAD 18-01 and 19-01 cruises. Expected accuracy is on the order of 2-4%. Most of the data has not been evaluated but some general observations can be made. Surface values of phosphate were generally higher than those of the summer and at no time did we find total depletion as observed then. Surface silicate values were also higher than those of the summer and also were very uniform in areal distribution.

Weather Observations

Air temperature and dew point sensors were located in a weather station mounted on the 02 level of the CONRAD. A sea-surface temperature sensor was towed between all stations except near the end of the cruise when the probe became entangled in the ship's propellors and was lost. All three parameters were recorded on a continuous strip chart throughout the cruise. Unfortunately, the pre-set ranges of the recording equipment had a lower limit of -2°C and air temperatures and dew points below -2°C could not be recorded. During the cruise the air temperature was frequently below -2°C and the dew-point was mostly below -2°C.

Standard weather observations were made at each STD station. Continuous barometer records were maintained throughout the cruise.

Geochemistry

Radon

A total of 81 radon profiles (627 samples) were taken during R/V CONRAD 19-05. Most profiles consisted of 8 samples, most of them taken in the radon excess zone near the bottom of the ocean. The greater number of samples taken than during any previous cruises is due to two factors: all radon analyses were done by the newer charcoal method and all radon extraction boards had been made identical for this cruise. It has been our constant intention to standardize and simplify as much as possible the radon analyses.

Immediately upon the return of the Niskin bottles to the deck, 19 liter water samples were drawn into evacuated flint glass bottles. In deep water, millipore filter holders were inserted between the Niskin bottles and the flint glass bottles. In shallow, more turbid water, no filter holders were inserted. The radon extraction was performed 8 samples at a time. The total time involved for extraction, purification and transfer to counting chambers of the radon was about 2 hours per 8 samples. The counting time was a minimum of 2 hours, depending on radon content and availability of counting time.

A total of 37 samples were acidified and kept for ulterior Ra^{226} analyses.

Pump Stations

A total of 78 pump stations were occupied during the cruise of R/V CONRAD 4-21 January 1976. The purpose of the sampling program was to collect large volume seawater samples for the analysis of radioisotopes. As part of a continuing program of the geochemistry section, it is believed that radioisotope concentrations can provide information concerning the fate of pollutant metals in the New York Bight and concerning rates of mixing of shelf and slope waters.

Surface water samples were collected with a Jabsco pump mounted on the deck of the ship. Subsurface samples were collected by lowering a submersible pump. The maximum depth to which the pump could be lowered was 100 m. Subsurface samples were collected when the STD indicated that different water types could be reached with the pump.

In an effort to determine the amount of radioisotopes in the particulate matter, about one-half of the samples were filtered before analysis. Water which was to be filtered was pumped into four 200 l tanks. The water was fed from these holding tanks through a large diameter filtering device into the processing tank. The water in the processing tanks was then treated to concentrate the radioisotopes into a small volume which could be returned to the laboratory for further analysis. Samples which were not to be filtered were pumped directly into the processing tanks. Radioisotopes which were collected in this manner included Th-228, Ra-228, Cs-137, Pu-239, Pb-210 and Po-210.

Particulates

Turbidometer, Filter and Coulter Counter

In addition to the in situ measurement of particulate concentration as obtained with the Nephelometer three other methods were utilized to determine the amount, composition, and size distribution of suspended particulate material. The first method was the determination of optical density with a Hach Turbidometer and served as the only immediate indication of particulate concentrators on board. Samples for this determination were drawn in triplicate immediately after the radon sampling had been completed. These were then dispersed with 5 seconds of ultrasonic vibration and measured. The second method used was the relative size range determinations on the Coulter counter. Samples for Coulter determination were drawn after the radon sample and in most cases processed within 1 hour of sampling. We have made storage tests which have shown little significant change in the size and distribution of samples stored cold up to 12 hours. The third method, and the one which yields data on particulate mass and composition is the direct concentration of the particulates by filtering through 0.4 micron nucleopore filters in 47 mm "in line" holders. For the near shore samples approximately 10 l of water or less was filtered, in deeper stations additional water was filtered by drawing the radon samples through the filters. The majority of filters were preweighed and blanks were run. In addition to the measurement of total particulate mass the filters will be sectioned and analysed on an electron microscope equipped with an EDAX (X-ray) system to allow qualitative determinations of the elemental composition. Results from our previous shelf cruises show the impact of human activities in the near shore zone as demonstrated by particles enriched in iron, zinc, titanium, and other trace metals. Results from all three types of particulate measurements generally show the marked differences between particulate rich shelf waters and relatively clean slope waters. Also of note is the local concentration of turbid water associated with the Hudson Canyon and Channel.

Nephelometer/Camera

Thirty-two nephelometer stations were made, 29 of these with the wire -acounted nephelometer and 3 with the standard nephelometer/ camera instrument. During this cruise less emphasis was put on the camera work than on the two previous cruises as it was felt that sufficient camera stations have been taken in the area already.

The nephelometer was placed on the wire as close to the STD as the weather conditions would permit. Those stations where the URI logging system was used to record the STD data have the advantage of a continuous teletype record of time versus STD depth. This will enable an accurate correllation to be made between rise time and the nephelometer record to obtain a good nephels v/s depth profile. Although many of the stations were very shallow we expect to get a good percentage of usable nephelometer data on the shelf as all these stations were taken at night. Most of the shallow stations show the expectedly very turbid water on the shelf and in the surface waters elsewhere. Horizontal stratification was visible on several stations but we will have to wait for final data analysis before we can see how these layers may correlate with the hydrographic data. Nephelometer stations were run on most of the time-series STD casts to examine the time-dependability of particulate distribution at the shelf break.

Sediments

The sediment sampling program on CONRAD 19-05 was planned assuming that poor weather and lack of time would limit the type and number of samples collected. As a result the Sanders 3" and 6" gravity corer was not used and a smaller 2-1/2" gravity corer was employed. A large box corer was tried early in the cruise but this program was abandoned due to the extensive time required to take a core and its malfunctioning due to design problems. In total nine gravity cores and five piston cores were taken. These cores were taken predominately in the Hudson Channel and Canyon regions. Sediment surface samples over the broad area were also collected for the purpose of establishing the radon source function, distribution of sediment type and compositions, and trace metal concentrations. Shipek grab samples were taken at almost every station, usually in duplicate. Following sieving to determine percent fines and subsectioning into radon kettles the samples were transferred to plastic containers for further analysis at the laboratory.

Biological Oceanography

Plankton

The surface waters of the continental slope, in the New York Bight, were sampled with a large ($1m^2$) plankton net. A total of 13 plankton tow samples were collected on cruise CONRAD 19-05. (See Table 1). Six stations were sampled where the water depths were greater than 200 fathoms. At each station, two plankton tows were taken. Of these two tows, one was directly preserved in five percent buffered formalin, the other was frozen with no preservatives added. In addition to the plankton tow samples, an 0^{18} water sample was collected and preserved in mercuric chloride ($Hgcl_2$), and a surface water temperature measurement was recorded using a bucket thermometer and STD information.

Benthos

Fifty-one stations were qualitatively sampled for macrofaunal and meiofaunal organisms using a shipek grab sampler. After subsampling the grab sample for sediment fine-fraction analyses, the excess sediment sample was prepared and preserved appropriately for qualitative analyses on the macrofaunal and meiofaunal groups. Samples from 29 stations were collected for study on the meiofaunal organisms (See Table 2). The macrofauna station samples were directly preserved in five percent buffered formalin. In five of these stations, the sediment was washed and sieved through a 149 micron sieve to reduce the bulk sediment volume. In the 29 meiofauna samples, the meiofauna were extracted from the sediment

TABLE 3 LOCATIONS AT WHICH SURFACE PLANKTON TOWS WERE COLLECTED ON RC 19-05

Station #	Plankton tow #	Median Position	Duration of tow (min.)	Type of preservation
114	1	39° 18.4'N 72° 00.2'W	82	Frozen
114	2	39° 16.7'N 71° 02.9'W	55	Formalin
124	3	39° 00.1'N 72° 14.6'W	60	Formalin
124	4	39° 00.1'N 72° 14.6'W	80	Frozen
125	5	38° 45.7'N 71° 57.2'W	60	Formalin
125	6	38° 45.6'N 71° 57.1'W	60	Frozen
125	7		75	Frozen
159	8	39° 34.3'N 71° 57.6'W	45	Formalin
159	9	39° 33.5'N 71° 58.4'W	60	Frozen
163	10	39° 33.6'N 71° 57.9'W	50	Formalin
163	11	39° 33.1'N 71° 54.4'W	35	Frozen
164	12	39° 27.9'N 72° 14.7'W	60	Formalin
164	13	39° 26.6'N 72° 14.9'W	55	Frozen

TABLE 4 STATIONS AT WHICH QUALITATIVE SHIPAK GRAB SAMPLES WERE COLLECTED FOR MACROFAUNAL AND MEIOFAUNAL ORGANISMS ON RC 19-05

Meiofauna Sample Stations (29)	105, 154, 122, 142, 99, 144, 145, 135, 137, 130, 143, 146, 79, 96, 129, 147, 141, 139, 140, 131, 133, 132, 134, 170, 148, 149, 169, 167, 150,
Macrofauna Sample Stations (26)	87, 94, 136, 93, 101, 104, 97, 169, 152, 166, 129, 103, 165, 138, 167, 102, 140, 92, 128, 153, 96, 127, 84*, 90*, 85*, 86*,

* 149 micron sieved to reduce sediment volume

using the anaesthetization technique of Hulings and Gray (1971). This technique basically involves anaesthetizing the organisms with a magnesium chloride solution ($Mgcl_2$), pouring the supernatant containing the meiofauna through a 62 micron sieve to retain the organisms, and finally preserving the retained meiofauna in five percent buffered formalin.

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APPENDIX iii

THE NEW YORK BIGHT & HUDSON CANYON IN OCTOBER 1974

PART 1. HYDROGRAPHY, NEPHELOMETRY, BOTTOM PHOTOGRAPHY, CURRENTS

By

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THE NEW YORK BIGHT & HUDSON CANYON IN OCTOBER 1974

PART 1. HYDROGRAPHY, NEPHELOMETRY, BOTTOM PHOTOGRAPHY, CURRENTS

1 INTRODUCTION

This report presents data collected in the last two weeks of October 1974 from Lamont-Doherty Geological Observatory's research vessel VEMA during the first of a series of cruises designed to examine the seasonal variations in the physical oceanography and geochemistry of the New York Bight. This work was supported by the Energy Research and Development Administration (ERDA), grant AT(11-1)2185; Part 1 presents the physical oceanography data which includes the hydrography, nephelometry, bottom photography and currents. For the purpose of this report to ERDA, only samples of the data are given. The actual data report is being reproduced for distribution at the present time.

The aim of the project is to understand the interaction between shelf, slope and oceanic waters and the mechanisms that determine the fate of pollutants discharged into the New York Bight. Using techniques developed at Lamont primarily for deep-ocean studies, a multidisciplinary program of study was made possible, using a larger research vessel than is normally employed in coastal oceanography, and extending the study area across the continental shelf to the shelf break and continental slope.

The station map (Fig. 1) shows the three parallel transects normal to the isobaths; one coincident with the Hudson Canyon and one each across a relatively smoother portion of the shelf and upper slope to the northeast and southwest of the canyon. Shorter sections were run across the Hudson Channel, the "delta" area and the canyon itself. At each station location one or more of the following types of measurements were made:

- continuous salinity and temperature profiles: surface to bottom
- discrete sampling and analysis for:
  - salinity
  - dissolved oxygen
  - nutrients
- continuous profiles of light-scattering, surface to bottom (nephelometry)
- bottom photography
- long-term canyon bottom-current and light-scattering measurements
- 30-liter sampling at discrete levels for analyses of:
  - dissolved radon
  - suspended particulate material
- large-volume sampling for analyses of:
  - radium and thorium-228 analysis
  - oxygen isotope at discrete levels
- sediment cores
- grab samples

Additionally, continuous underway sea-surface temperature, air temperature and relative humidity data were

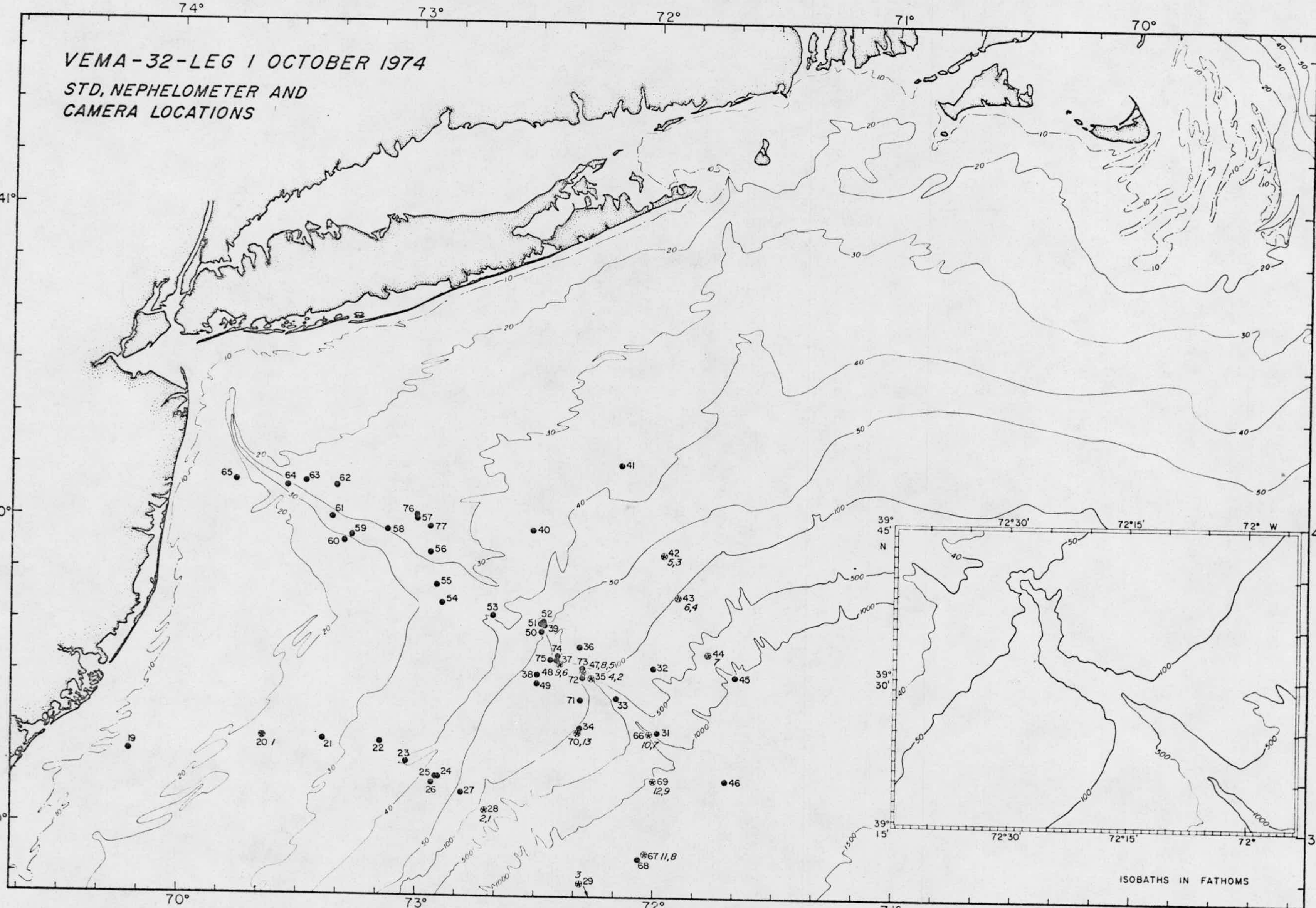


Figure 1 Key

Solid Circles = STD Stations, Numbered.

Circle & Star = STD + Nephelometer (and camera) Stations.

Italicized Numbers are neph meter sta # followed by camera station #. Canyon current [illegible]er staton is at STD #35 location.

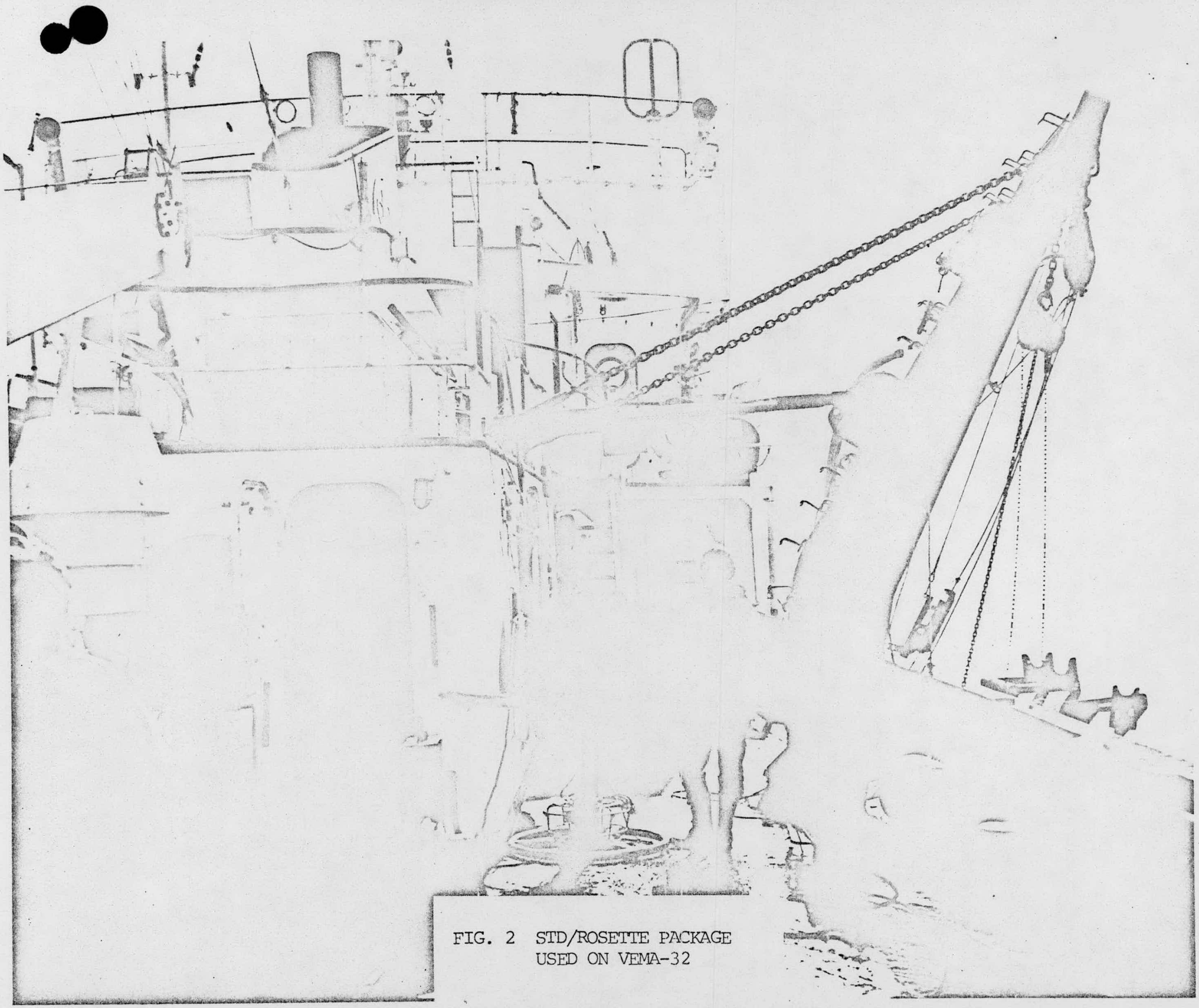


FIG. 2 STD/ROSETTE PACKAGE
USED ON VEMA-32

collected and continuous 12-kHz and 3.5-kHz echo-sounding records were obtained. Navigation was provided by LORAN-C and a Magnavox satellite navigation system.

Preliminary results from the first cruise have been presented in Amos et al. (1974) and Biscaye et al. (1974)

The following papers are now in preparation: Amos, Baker and Daubin (in prep.), Gordon, Amos and Gerard (in press), and Biscaye and Olson (in press).

2 HYDROGRAPHY

2.1 Instrumentation

A Plessey Model 9040 Salinity/Temperature/Depth (STD) system with a 3000-m fullscale depth sensor was used throughout the cruise. Recording was made on both analog strip-chart and on digital magnetic tape using a Plessey Model 8114 digital data logger. A General Oceanics Model RMS-12 rosette water-sampler with twelve 1.7-liter sampling bottles was attached to the STD sensor package (Fig. 2). Six of the bottles were equipped with frames to hold three deep-sea reversing thermometers. A Benthos Model 2113 bottom-finding pinger was used on all stations to allow close approach to the bottom without making contact.

2.2 Methods

The methods used were basically those detailed in Amos (1973). Briefly, the STD was lowered from the surface to within 1 to 5 meters of the bottom (depending on weather conditions and bottom topography) at a rate of 15-20 m/min in the shallow stations and increasing to a maximum of 50 m/min in the deep stations after the pycnocline was passed. Digital recording rate was at one scan (salinity, temperature, depth) every two seconds. The rosette bottles were then tripped as the STD was brought back to the surface (the uptrace). Twelve bottles were tripped on all but the very shallow stations. When thermometers were present on the bottle, a stabilization wait of from 3-5 minutes was necessary before tripping the bottle, otherwise they were tripped immediately after the STD package was stopped in the water.

The rosette samples and thermometric data were used for three main purposes:

(i) *in situ* calibration of the STD salinity, temperature and depth sensors;

(ii) discrete sampling for dissolved oxygen and nutrients;

(iii) verification of core layers, inversions etc., revealed by the STD.

In the event of a major breakdown of the STD system, the sample data would also provide adequate coverage of the water column to describe the hydrography.

Salinity samples were run on a Guildline Model 8400 Autosal salinometer. Oxygen determinations were made using the Carpenter modification of Winkler's method (Carpenter, 1965).

Both of these anlayses were run on board ship during the cruise. A trial nutrient program was run on some of the stations. Samples were frozen immediately after collecting and were analysed later at L-DGO using a Technicon Auto-analyzer. Nutrients determined were nitrate, phosphate, silicate and ammonia. In later cruises, nutrients will be determined on shipboard using a Beckman DU spectrophotometer.

2.3 Data Reduction

The first step in the data reduction process is the calculation of corrections to apply to the STD data using the salinities, temperatures and thermometric depths obtained from the rosette water-sampling bottles. Not all the samples were useful for this purpose, particularly in the many shallow stations, because several of the bottles had to be tripped at levels where there were high gradients in the water column. In these cases, and where narrow core-layers were sampled, the STD outputs vary when the ship's motion moves the sensors vertically in the gradients.

In a departure from our usual procedure (Amos, 1973), the difference between the uptrace STD output and rosette sample values (collected on uptrace) was used to correct the downtrace STD records presented in this report. Consequently, in some of the shallower levels, the sample salinities and temperatures appearing on the listings may not agree with the corresponding STD standard-level values. This is particularly so when changes in the upper water column occur during the time it takes for the STD to be lowered and raised again.

2.3.1 Salinity Correction

STD salinities have been corrected for two types of error, surface offset error and salinity/pressure error:

2.3.1.1 Surface offset error. [$\Delta S_{(surf)} = S_{(sample)} - S_{(STD)}$ at, or near the sea surface]. $\Delta S_{(surf)}$ is added to all STD salinities in a particular station: Therefore, at depth Z, $S_Z = S_{Z(STD)} + \Delta S_{(surf)}$;

$$\text{for } Z = 0, \; S_0 = S_{0(STD)} + S_{0(sample)} - S_{0(STD)}$$
$$= S_{0(sample)}$$

i.e., the salinity is forced to the sample salinity at the surface.

The variation of $\Delta S_{(surf)}$ with time (station number) during V-32-01 is shown in Figure 3. $\Delta S_{(surf)}$ showed a "normal" distribution (Amos, 1973) until station #68, when it started to increase rapidly. This was later found to be caused by a failure in one of the compensating probes in the salinity sensor. Despite this massive error, the data from stations 68-77 appeared to be consistent after correction for $\Delta S_{(surf)}$.

2.3.1.2 Salinity/pressure error. After correction for $\Delta S_{(surf)}$, STD salinities still differ from sample salinities by an amount that varies as a function of pressure (depth). Figure 4 shows ΔS_Z [$=S_{Z(STD)} + \Delta S_{(surf)}$] plotted against STD depth for all stations taken during the

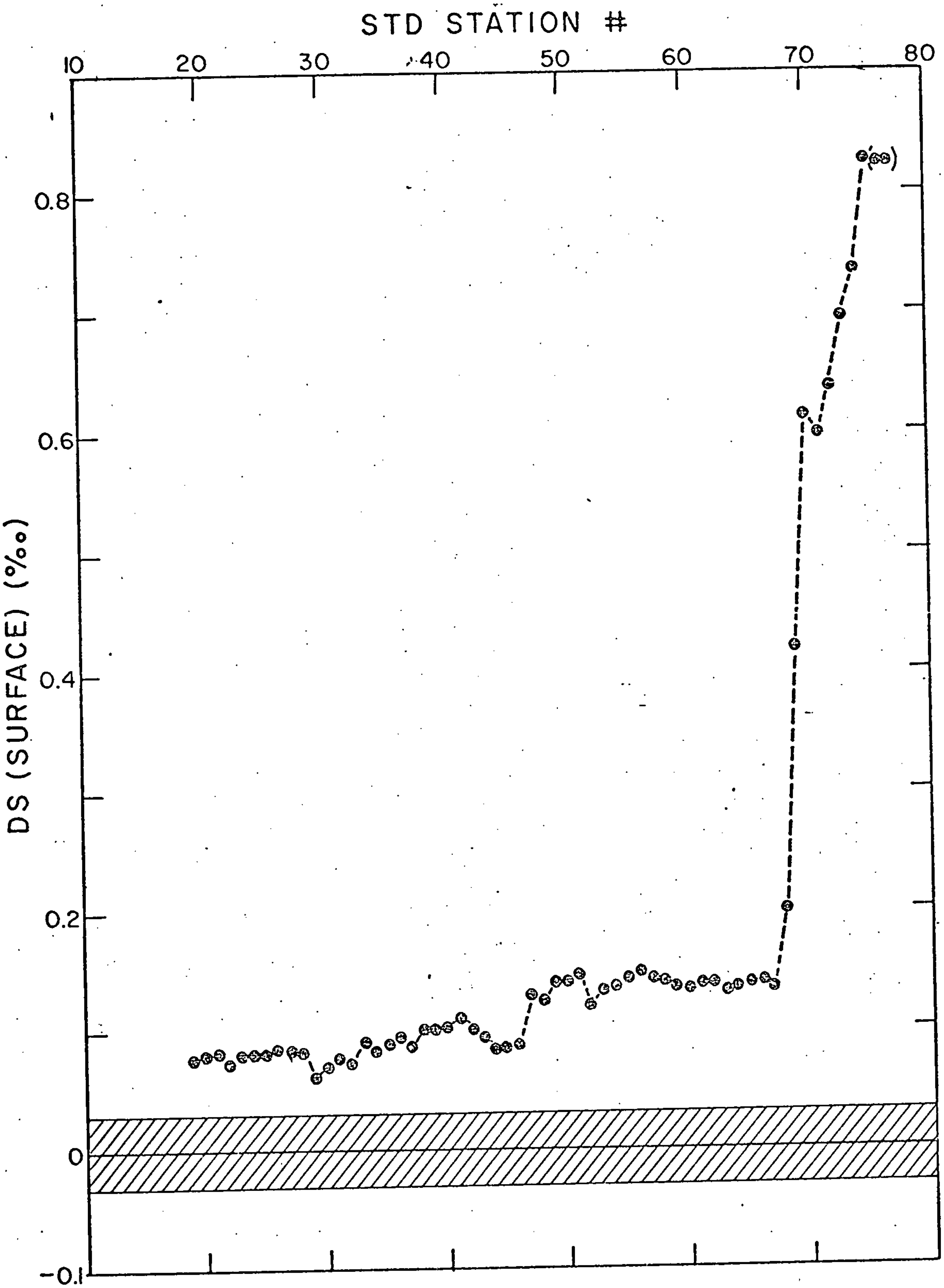
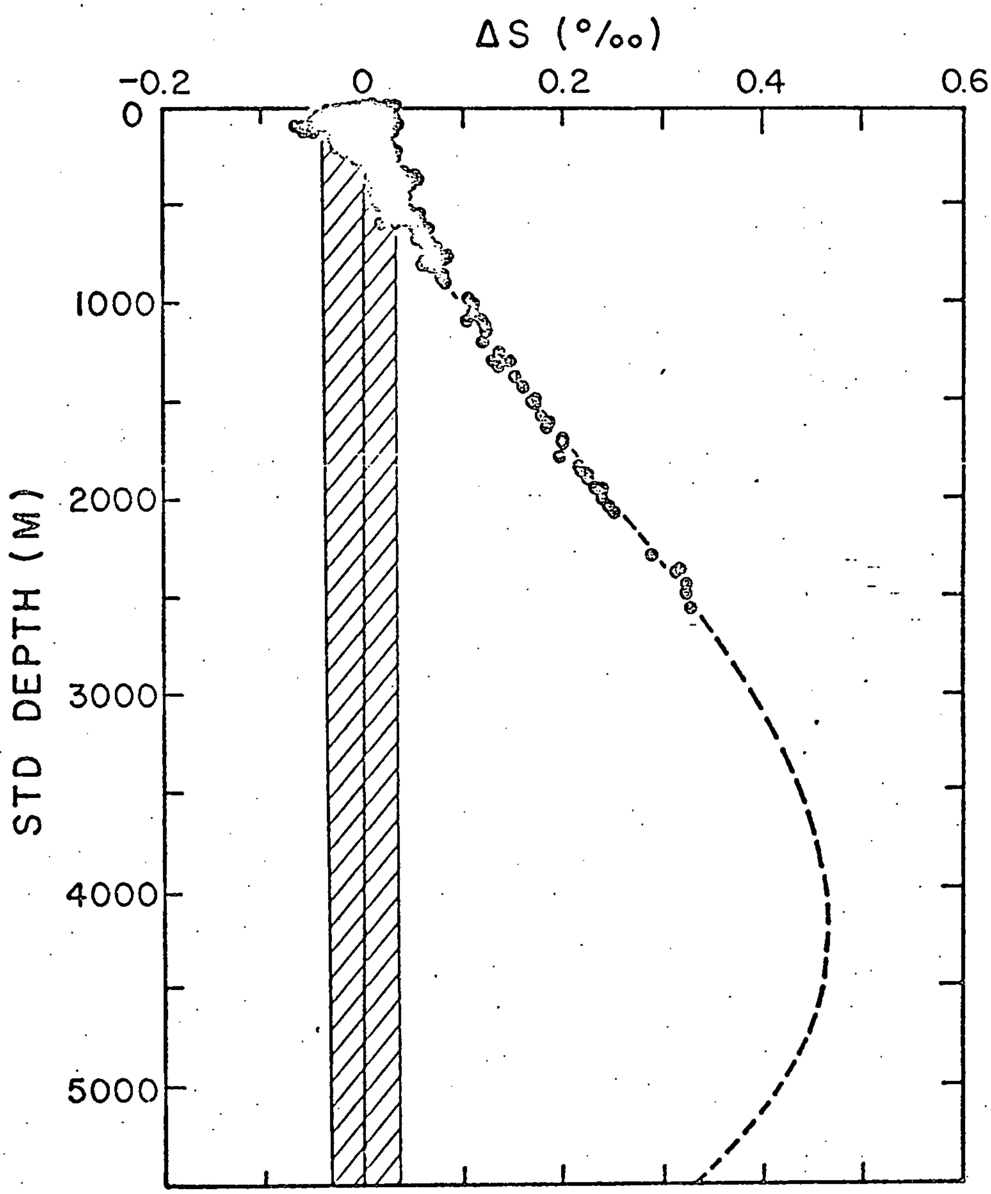


Fig. 3 STD SALINITY ERROR (1): SURFACE ERROR, ΔS (Surf), PLOTTED AS A FUNCTION OF STATION NUMBER. Shaded region is manufacturer's stated limits of accuracy. Rapid increase in Δ_S (Surf) after station #67 is explained in text.

Δ_S(Surf) = Salinity of surface sample - STD surface salinity



$$S_{(CORR)} = S_{(STD)} - 8.979 \times 10^{-10} D^3 + 4.83 \times 10^{-6} D^2 + 6.88 \times 10^{-3} D + \Delta S_{(SURF)}$$

S.D. = 0.022 °/oo

Fig. 4 STD SALINITY ERROR (2): Pressure dependent error ΔS (after normalizing by subtracting Δ_S(Surf) from all STD salinities for a given station) plotted as a function of depth. Dotted line is 3rd-order curve fitted to data. Shaded area is manufacturer's stated limits of accuracy. Equation used to correct salinities is given below figure.

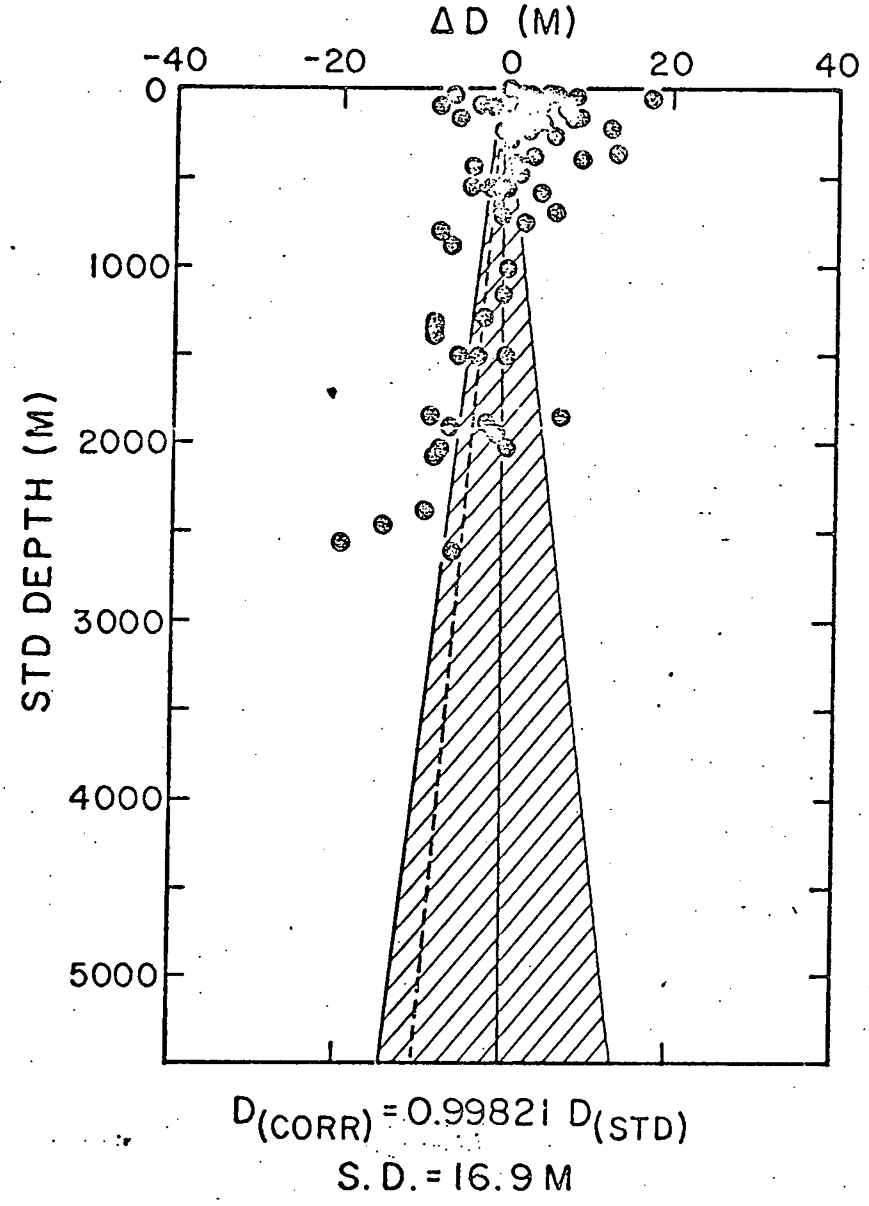
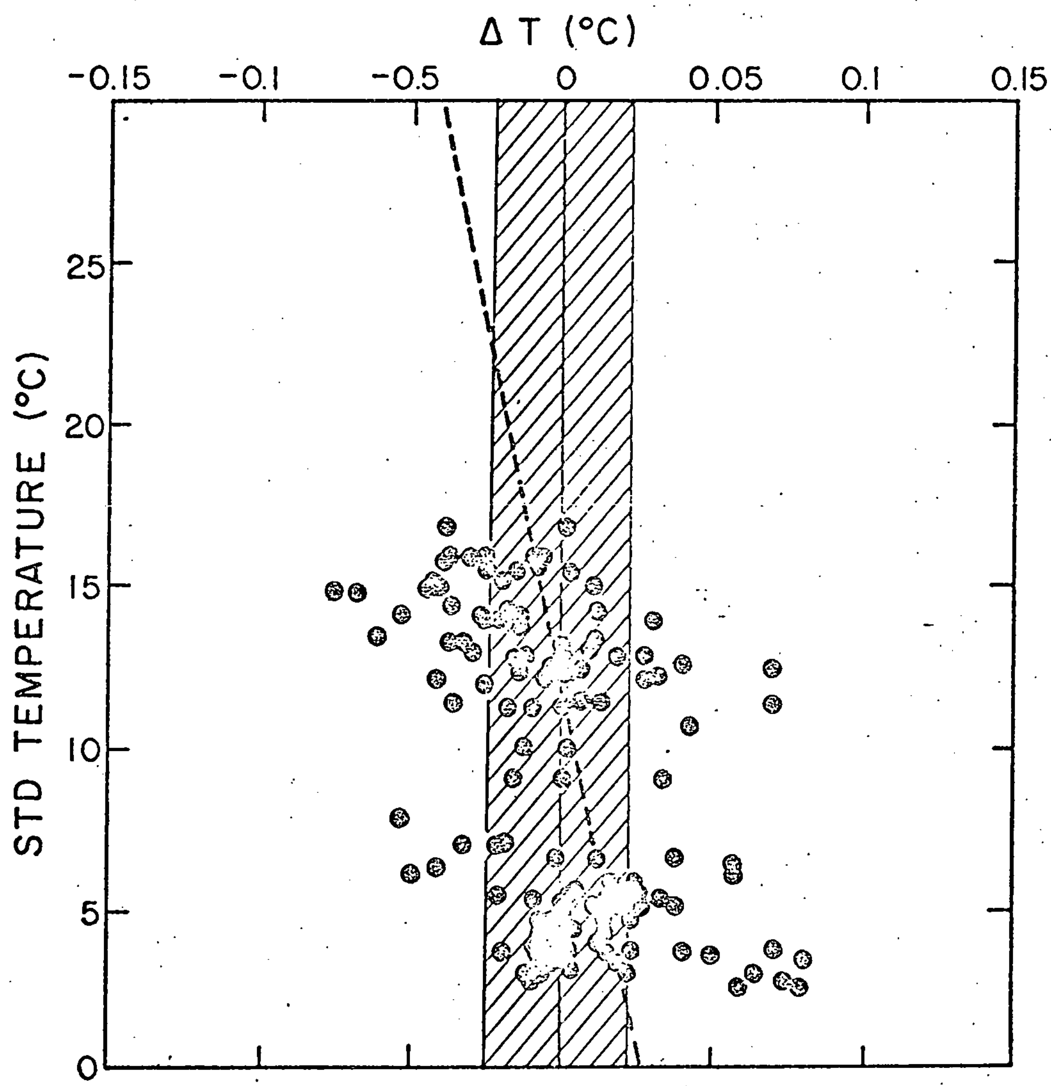


Figure 5. STD DEPTH ERROR: ΔD plotted as a function of STD depth. $\Delta_D = Z - D_{STD}$, where Z = thermometric depth. Shaded area indicates manufacturer's stated limits of accuracy. Dotted line shows linear correction curve used. Equation is given below figure.



$$T_{(CORR)} = 0.9977\ T_{(STD)} + 0.027$$

S.D. = 0.065 °C

Figure 6: STD TEMPERATURE ERROR: ΔT plotted as a function of STD temperature. Shaded area indicates manufacturer's stated limits of accuracy. Dotted line shows linear curve fitted to data. Equation is given below figure.

cruise. This error is caused by incorrect compensation for the effects of pressure on conductivity, a compensation that is effected electronically within the STD salinity sensor. A third-order curve was fitted to the data using a least-squares curve-fitting routine. As the deepest STD station was <2,500 m, the part of the correction curve below 2500 m is not used for correcting the STD data. The final equation used is given in Figure 4. Although the standard deviation of 0.025 $^{o}/oo$ is rather high, the greatest scatter occurs in the upper 100 m of the water column where, due to high gradients, a precise correction cannot be made. In the deeper waters, where even a small salinity error would be obvious, the scatter is much less.

2.3.2 Temperature Corrections

In Figure 5, ΔT $(=T_{(THERM)} - T_{(STD)})$ is plotted against STD temperature. $T_{(THERM)}$ are temperatures taken from paired protected reversing thermometers attached to the rosette bottles. A straight-line curve is fitted to all points taken during the cruise. The rather high point scatter is caused by frequent tripping of thermometers in high-temperature gradients.

2.3.3 Depth Corrections

In Figure 6, ΔD $[=D_{(THERM)} - \Delta D_{(STD)} - \Delta D_{(surf)}]$ is plotted against STD depth. $D_{(THERM)}$ = thermometric depth. Here $\Delta D_{(surf)}$ is the reading of the depth sensor when the STD is on deck (i.e., zero depth). $\Delta D_{(surf)}$ varies with time and somewhat with temperature and

TABLE 1

STD DEPTH (D_{STD})	SALINITY (°/₀₀)			TEMPERATURE (°C)			DEPTH (m)	
	S_Z	ΔS	S_{CORR}	T_{STD}	ΔT	T_{CORR}	ΔD	D_{CORR}
0	34.532	0	34.532	14.03	-0.01	14.02	0	0
390	35.016	0.016	35.032	6.64	0.01	6.65	-1	389
756	34.938	0.055	34.993	4.77	0.02	4.79	-1	755
1139	34.876	0.108	34.984	4.17	0.02	4.19	-2	1137
1509	34.805	0.166	34.971	3.84	0.02	3.86	-3	1506
1876	34.746	0.226	34.972	3.62	0.02	3.64	-3	1873
2456	34.631	0.317	34.948	2.97	0.02	2.99	-4	2452

$\Delta S(SURF) = 0.089$°/₀₀

$\Delta D(SURF) = -6$ m

Typical corrections applied to STD data. S_Z is the STD salinity at depth Z after subtracting surface offset correction. Δ_S is the correction applied to each S_Z to produce corrected salinity S_{CORR}. T_{STD} is the STD temperature. ΔT is the temperature correction applied to produce corrected temperature T_{CORR}. ΔD is the depth correction applied to D_{STD} to produce corrected depth D_{CORR}.

may amount to several meters. As it is known that the initial depth of all STD stations must be zero, the data are weighted by inserting one value of zero on each station even though there were no unprotected thermometers tripped at zero depth. Paired unprotected thermometers were used at many sample depths. A straight-line correction curve was fitted to all points taken during the cruise.

Table 1 gives some examples of the magnitude of corrections applied to the STD data. Data in Table 1 are taken from STD station #46 at selected depths where bottles were tripped.

2.3.4 Smoothing of STD Digital Data Records

The method used to smooth and remove spikes from the STD digital data was developed at Lamont by D. Georgi. Corrections were applied to the salinity data for dynamic errors introduced by the conductivity and temperature probe time-constant mismatch (Scarlett, 1975). To remove noise introduced into the salinity data by the dynamic corrections, the salinities were smoothed by a 15-point running mean.

Digitization noise ($\Delta T = .003°C$, $\Delta D = 0.3m$, $\Delta S = .0003^{o}/oo$) was removed by applying a 7-point running mean to all temperature and depth data. Subsequent to the application of dynamic salinity corrections and smoothing, all data points that were not 0.2 m deeper than the last accepted data point were rejected. Dynamic salinity cor-

TABLE 2. VEMA 32 Cruise 1 Station Locations.

Time is GMT time. STD was at surface immediately prior to lowering. Depth is corrected bottom depth at the time the STD sensor was closest to the ocean floor. Accompanying casts are the numbers of stations taken at the same location as the STD station but not at the same time. (except nephelometer casts 1, 3, 7, 13).

TABLE 2

STD CAST							ACCOMPANYING CASTS						
STD STA. NO.	TIME (Z)	DATE (1974)	LATITUDE (°N)	LONGITUDE (°W)	DEPTH (m)	SOURCE*	N	K	SG	RN	P	C	F
19	1651	18-10	39 14.3	74 12.3	28	T			4	3			
20	2209	18-10	39 17.2	73 38.7	44	T	1		5				
21	0022	19-10	39 16.7	73 23.5	47	T			6	4	3		
22	0518	19-10	39 16.48	73 09.1	59	T							
23	0731	19-10	39 12.7	73 02.6	68	T							
24	0936	19-10	39 09.7	72 54.5	84	T							
25	0955	19-10	39 09.7	72 54.9	84	T							
26	1240	19-10	39 08.6	72 56.0	86	D			7	5	4,5		
27	1557	19-10	39 06.5	72 48.5	110	T			8	6			
28	1848	19-10	39 03.1	72 42.6	364	T	2	1	9	7		3	
29	2304	19-10	38 40.9	71 58.9	2684	T	3		10	8	6		
30	-----data irrecoverable-----												
31	1901	21-10	39 18.6	71 58.9	1995	D			11	9			
32	0124	22-10	39 31.1	72 00.1	617	D				10			
33	0529	22-10	39 25.4	72 09.3	1098	D					8		
34	1012	22-10	39 19.2	72 18.6	214	T			12	11	9		
35	1727	22-10	39 29.3	72 15.8	710	T	4	2		12			
36	2028	22-10	39 35.2	72 18.8	113	T			14	13	10,11		

TABLE 2 (continued)

		S T D	C A S T				ACCOMPANYING CASTS						
STD STA. NO.	TIME (Z)	DATE (1974)	LATITUDE (°N)	LONGITUDE (°W)	DEPTH (m)	SOURCE*	N	K	SG	RN	P	C	F
37	0007	23-10	39 32.4	72 24.7	525	T			15	14			
38	0358	23-10	39 29.5	72 29.7	112	T			16				
39	0758	23-10	39 39.1	72 27.8	238	T			17	15	12		
40	1317	23-10	39 57.5	72 30.7	64	T			18	16	13		
41	1801	23-10	40 10.2	72 08.6	69	T			19	17	14		
42	2120	23-10	39 53.0	71 57.3	110	T	5	3	20	18	15		
43	0059	24-10	39 45.1	71 54.1	243	T	6	4	21				
44	0351	24-10	39 33.5	71 45.9	1353	T	7		22	19	16		
45	0938	24-10	39 29.5	71 39.3	1885	T				20	17		
46	1826	24-10	39 09.1	71 41.7	2408	T			23	21	18		
47	1305	25-10	39 30.3	72 17.8	435	T	8	5		22	19	4	
48	1905	25-10	39 31.8	72 23.9	584	T	9	6		23		5	
49	2326	25-10	39 28.0	72 29.6	115	T				24		6	
50	0519	26-10	39 38.0	72 28.6	91	T							
51	0644	26-10	39 39.6	72 28.6	141	T			25		20		
52	0723	26-10	39 39.8	72 28.0	225	T				25			
53	1039	26-10	39 41.1	72 40.7	70	T			26				

TABLE 2 (continued)

S T D C A S T							ACCOMPANYING CASTS						
STD STA. NO.	TIME (Z)	DATE (1974)	LATITUDE (°N)	LONGITUDE (°W)	DEPTH (m)	SOURCE*	N	K	SG	RN	P	C	F
54	1244	26-10	39 43.6	72 53.7	70	T			27	26			
55	1420	26-10	39 46.9	72 55.0	70	D			28				1
56	1545	26-10	39 53.2	72 56.7	53	D			29		21		2
57	1714	26-10	39 59.9	73 00.3	46	T			30	27	22		
58	1953	26-10	39 57.6	73 07.7	64	D			31				3
59	2210	26-10	39 56.5	73 16.8	75	T			32		23		4
60	2348	26-10	39 55.5	73 18.4	44	T			33				5
61	0124	27-10	40 00.1	73 21.5	75	T			34	28			
62	0333	27-10	40 06.0	73 20.5	40	T			35	29			
63	0538	27-10	40 06.8	73 28.3	40	T			36				
64	0655	27-10	40 06.1	73 32.9	68	T			37				6
65	0908	27-10	40 06.9	73 45.9	29	T			38		24		7
66	0849	28-10	39 18.3	72 00.8	659	T	10	7		30	25,26	7	
67	2118	28-10	38 53.6	72 01.8	1781	T	11	8	39	31	27		
68	2357	28-10	38 53.8	72 03.5	2535	T			40	32	28		FB1
69	1402	29-10	39 09.1	71 59.9	1965	T	12	9	41	33			
70	2158	29-10	39 18.6	72 19.1	216	T	13			34	29	8	
71	0150	30-10	39 25.1	72 18.5	152	T							8

TABLE 2 (continued)

S T D CAST							ACCOMPANYING CASTS						
STD STA. NO.	TIME (Z)	DATE (1974)	LATITUDE (°N)	LONGITUDE (°W)	DEPTH (m)	SOURCE*	N	K	SG	RN	P	C	F
72	0315	30-10	39 29.2	72 17.9	525	T							9
73	0504	30-10	39 31.0	72 18.1	289	T							10
74	0639	30-10	39 33.4	72 24.4	425	T							11
75	0820	30-10	39 32.7	72 26.2	247	T							12
76	1317	30-10	40 00.5	73 00.3	48	T				35	30		
77	1653	30-10	39 58.2	72 56.9	49	T							

N = nephelometer; K = camera; SG = Shipek grab; RN = radon cast; P = pump station; C = core (3" Sanders); F = filter station.

*Source of final STD data T=Magnetic Tape; D=Digitized from Analog Trace.

rections were applied only to the upper 1000 m of the water column where thermal gradients were high. Below 1000 m the digital data tapes were subsampled at a rate of one out of four scans for sampling efficiency and then a 7-point running mean was applied for smoothing.

Some stations had problems with the digital data logging and the analog records were digitized by hand. Here, smoothing was done in a subjective way, commonly known as "eyeballing." Table 2 lists the pertinent data on all STD stations showing what type of data processing was used.

3 NEPHELOMETRY

The light-scattering measurements taken during V-32-01 were obtained from the standard Lamont photographic nephelometer developed by Ewing and Thorndike (Thorndike and Ewing, 1967; Thorndike, 1975; Sullivan et al., 1975).

This instrument photographically records the intensity of light scattered off of particles in the water column between the angles of 8° and 24°. The light source is a battery-powered, 0.25 amp, incandescent bul , 61 cm away from the camera. Variations in the output of the light source are recorded by the camera as the images of light passing directly from the source to the camera through three neutral density filters. These variations must be subtracted from the scattered light intensity to obtain the true variations in light scattering.

Depth is indicated by changes in pressure measured by a Bourdon-tube pressure gauge. These readings are recorded photographically along the edge of the film. One minute time marks are superimposed on the depth record.

The relation between the optical density of the direct and scattered light images on the film, and the amount of light required to produce them is determined from a calibrated sensitometer patch imaged on the film. Thirteen neutral density attenuator steps, each varying by 0.2 log exposure units (i.e., light intensity) from the previous one, are used to produce a corrected log exposure value (Log E).

The recording camera has a shutterless 35-mm F-2 lens and transports 35-mm nonperforated film past a 4.8-mm aperture at a nearly constant speed of 20 mm/minute. At this speed and aperture setting, a point on the film remains exposed for approximately 15 seconds. Thus, the detail of the record depends on how fast the instrument is lowered: faster speeds produce shorter, less detailed, records than do slower lowering speeds.

During V-32-01 (and all subsequent New York Bight cruises) the nephelometer was used in two modes: (1) in a combination camera-nephelometer mode where the instrument was purposely run into the bottom, triggering the camera

(2) in a combination STD-nephelometer mode, where the nephelometer was attached to the STD conducting cable above the STD, and lowered as close as possible to the bottom without touching it. This provided a useable ascent record as well as better depth control (dealt with further in section 8.2.1). Since sunlight penetrates almost 150 m in daylight (most stations were shallower than this), nearly all shallow-water stations were taken at night. Ship's lights at night did not adversely affect the record when the instrument was in the water. Therefore, a true record of light scattering was obtained from the surface to the bottom in most cases.

4 BOTTOM PHOTOGRAPHY

Photographs of the ocean bottom were taken with the Thorndike camera/nephelometer (Thorndike, 1975; Sullivan et al., 1975) at eight locations (Fig. 1). A trigger-weight hangs below the instrument on 2-m of line. When the weight is lowered until it is on the bottom, a strobe is flashed and a single picture taken. The trigger-weight can be seen in most photographs. Up to 12 photographs were taken per location. The field of view of the bottom camera is a trapezoid with dimensions of 5.5' x 5' x 6.5'. A compass is included in the field of view for orientation of ripple-marks, scour, bending or swimming organisms, etc.

5 LONG-TERM CURRENTS AND LIGHT-SCATTERING

A single near-bottom current and nephelometer record was obtained in the Hudson Canyon at 39°29.8'N; 72°17.6'W (Fig. 1) at a water depth of 827 m. A Geodyne Model 102 film-recording current-meter was deployed in a bottom-moored array with its rotor 5 m above the canyon floor. A modified Lamont nephelometer was attached to the mooring line 4 m above the current-meter. Immediately above the nephelometer, a subsurface buoy provided flotation and the package was anchored via two Geodyne timed-release devices mounted in tandem. Current and nephelometer data was recorded from 2 September 1974 to 25 October 1974, a total of 53 days. Current speed and direction were averaged over a one-minute period every 10 minutes and nephelometer data recorded as a single strobe picture of the light-scattering every 30 minutes.

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Physical Oceanography

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Computer

W. Brown

H. Poppe

Coring

M. Antle

C. Knickle

L. Knickle

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Geochemistry

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R. Hesslein

C. Kent

G. Kippluct

G. Mathieu

L. Miller

Gravity

V. Paisley-Smith

Electronics

C. Guttierrez

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J. Garside

Anastasia Sotiropoulos

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Amos, A.F., T.N. Baker and S.C. Daubin,Jr. (in prep) Near-bottom currents and sediment transport in the Hudson Canyon.

Biscaye, P.E., G. Mathieu, R. Hesslein, D. Hammond and C. Olsen, 1975. Geochemical studies of mixing on the shelf and upper continental slope: New York Bight. (abstract) 7th Long Island Sound Conference, N.Y.C., Jan.11, 1975.

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8 THE DATA

8.1 Hydrography

8.1.1 Explanation of Plots and Listings

Each STD station is presented as vertical profiles of temperature and salinity plotted on three different depth scales (0-100 m; 0-500 m; 0-2500 m). The same temperature and salinity scales are used throughout (0-20°C; 34-36^{o}/oo). Each profile is identified by a letter T or S. The data are plotted as individual points. Following this is a listing of observed-level data (rosette samples collected at the same time as the STD station was taken) and a standard-level listing.

In the header, most data are given for the time when the station started with the exception of corrected depth, which is the depth when the STD was at its closest approach to the bottom. The following descriptions are given for those data in the header that are not self-explanatory:

WIND	- direction in degrees and speed in knots
SEA	- direction in degrees and sea-state (Beaufort)
AIR TEMP	- °C
DEW POINT	- in this cruise, wet-bulb temperature in °C
BAROM	- barometer in millibars

STD	-	model number
SAL SENSOR		serial numbers of individual sensors;
TEMP SENSOR	-	in this cruise all are the same as we
DEPTH SENSOR		used a 9040 STD where all sensors are in the same package
NO OBS	-	number of rosette samples collected with each station.

The column headings for the listing are:

DEPTH	-	depth (m)
TEMP	-	temperature (°C)
SALIN	-	salinity ($^{o}/oo$)
DENS	-	density (σ_t units)
ANOM	-	specific volume anomaly
DELTA	-	dynamic depth (m)
VELOC	-	sound velocity ($m.sec^{-1}$)
OXYG	-	dissolved oxygen ($ml.l^{-1}$)
PHOS	-	phosphate ($\mu g\text{-}at.l^{-1}$)
NITR	-	nitrate (")
SIL	-	silicate (")
ALK	-	alkalinity (not done on this cruise)
NO_2	-	nitrite ($\mu g\text{-}at.l^{-1}$)
AMM	-	ammonia (")

In the observed-level data (OBS), the depths are corrected STD depths except where a good thermometric depth was used (*). Temperature only appears when thermometers were used on the bottle and gave good readings. Salinity is sample salinity: blanks will appear when there was no sample collected at that level. When depth, temperature and salinity all appear at one level, σ_t and sound velocity are computed.

For the standard-level listing (STD), data are linearly interpolated to the following depths: 0-100 m at 10-m intervals; 100-200 m at 20-m intervals; 200-300 m at 25-m intervals; 300-1000 m at 50-m intervals, and >1000 m at 100-m intervals. The deepest "observed" level is also included as a "standard" level. The column INT is the interval in meters over which the standard level was interpolated and gives an indication of lowering speed and gaps in the STD record. If INT is larger than the distance between adjacent standard levels then errors occur in the interpolation. Some stations with such gaps have been left in the data report as data below the erroneous portion is good (dynamic computations will still be in error, however).

Temperature/salinity diagrams for each station appear next to the standard-level listing. The scales are 32-36.4 $^{o}/oo$ for salinity and 0-20°C for temperature. The T/S curves are depth-annotated at the shallowest and deepest "observed" levels and at the nearest observed depth to the following intervals: 100-500 m every 100 m; >500 m every 500 m.

8.1.2 Sample Hydrographic Data

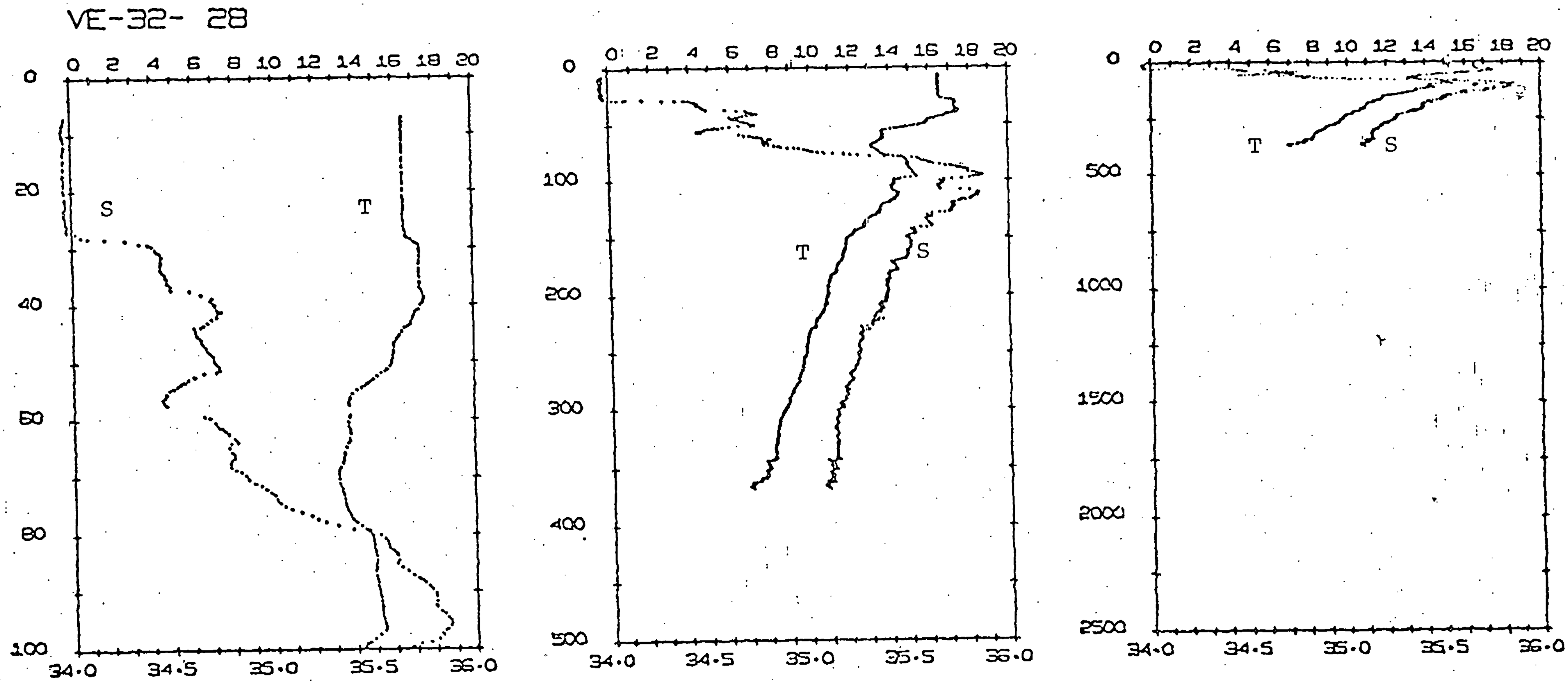
Figure 7.	STD Station	VEMA 32-28	Vertical Profiles
Figure 8.	STD Station	VEMA 32-28	Observed & Standard Level Listings & T/S Diagram
Figure 9.	STD Station	VEMA 32-45	Vertical Profiles
Figure 10.	STD Station	VEMA 32-45	Observed & Standard Level Listings & T/S Diagram

FIGURES 7, 8, 9, 10.

Samples of final data from STD/Rosette stations.

- Figures 7 and 9 are T & S profiles plotted on 0-100, 0-250 and 0-2500 m scales for stations 28 and 45.

- Figures 8 and 10 are observed sample level data (from Rosette), standard level data (interpolated from STD profiles) and T/S diagram for stations 28 and 45. (See text for detailed description.)



VE-32- 28
0 2 4 6 8 10 12 14 16 18 20
0
20
40
60
80
100
S
T
34.0 34.5 35.0 35.5 36.0
0 2 4 6 8 10 12 14 16 18 20
0
100
200
300
400
500
T
S
34.0 34.5 35.0 35.5 36.0
0 2 4 6 8 10 12 14 16 18 20
0
500
1000
1500
2000
2500
T
S
34.0 34.5 35.0 35.5 36.0

FIGURE 7.

VE 32 STA 28 DATE 19 10 74 GMT 2250 LAT 39 2.8N LONG 72 43.9W

CORR DEPTH 364M WIND 50 5 SEA 50 4 AIR TEMP DEW PT BAROM 1015.5

STD 9C40 SAL SENSOR 5312 TEMP SENSOR 5312 DEPTH SENSOR 5312 NO OBS 12

	DEPTH	TEMP	SALIN	DENS	ANOM	DELTA	VELOC	OXYG	PHOS	NITR	SIL	ALK	NO2	AMM
CBS	13		33.964					5.62						
CBS	23		33.985					5.62						
CBS	89		35.880					3.74						
CBS	146		35.636					3.50						
CBS	176		35.422					3.15						
CBS	215		35.304					3.09						
CBS	263		35.209					3.15						
CBS	314		35.126					3.49						
CBS	326		35.125					3.48						
CBS	335		35.120					3.52						
CBS	342		35.119					3.50						
CBS	364	7.87	35.108	27.40			1488.5	3.65						

	DEPTH	TEMP	SALIN	DENS	ANOM	DELTA	VELOC	INT
STD	0	16.54	33.969	24.85	310.83	0.000	1510.9	7
STD	10	16.53	33.955	24.84	311.93	0.031	1511.0	0
STD	20	16.53	33.959	24.85	311.95	0.062	1511.2	0
STD	30	17.30	34.410	25.01	296.89	0.093	1514.2	1
STD	40	17.37	34.707	25.22	277.07	0.121	1514.9	0
STD	50	15.88	34.703	25.57	244.41	0.148	1510.6	0
STD	60	13.71	34.684	26.02	201.21	0.170	1503.8	1
STD	70	13.15	34.855	26.27	178.03	0.189	1502.3	1
STD	80	14.78	35.506	26.43	163.45	0.206	1508.6	1
STD	90	15.11	35.784	26.57	150.44	0.222	1510.2	1
STD	100	14.32	35.666	26.65	142.80	0.236	1507.7	1
STD	120	13.75	35.720	26.77	131.95	0.264	1506.9	0
STD	140	12.77	35.614	26.93	117.05	0.289	1503.2	1
STD	160	11.77	35.501	27.04	107.16	0.311	1499.9	0
STD	180	11.31	35.407	27.05	106.07	0.332	1498.5	1
STD	200	10.89	35.386	27.11	100.74	0.353	1497.4	1
STD	225	10.30	35.312	27.16	96.48	0.378	1495.5	1
STD	250	9.79	35.243	27.20	93.56	0.401	1494.0	1
STD	275	9.39	35.206	27.23	90.28	0.424	1492.9	0
STD	300	8.69	35.135	27.29	84.83	0.446	1490.6	1
STD	350	7.93	35.109	27.39	76.14	0.487	1488.5	1
STD	367	7.06	35.086	27.50	65.49	0.499	1485.4	0

BOTTOM DEPTH= 367M

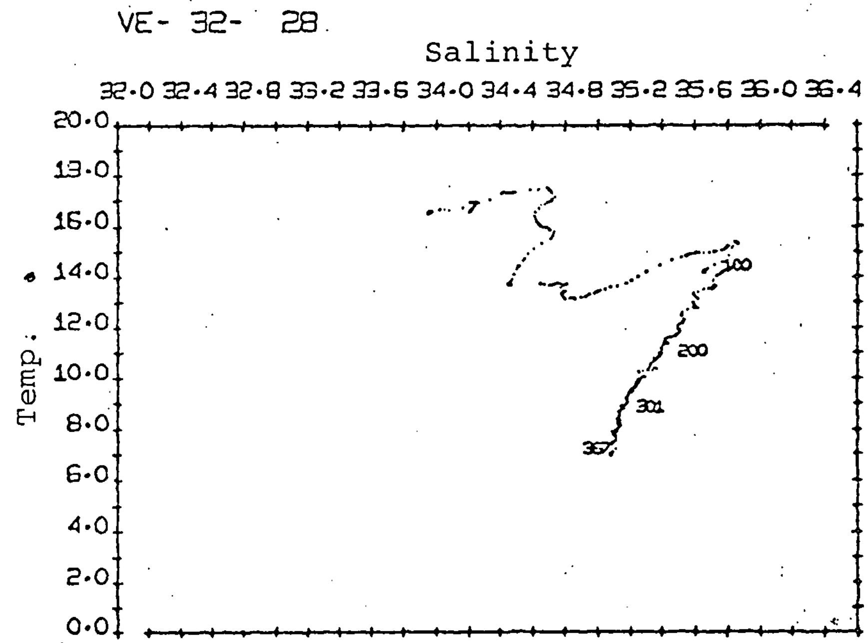
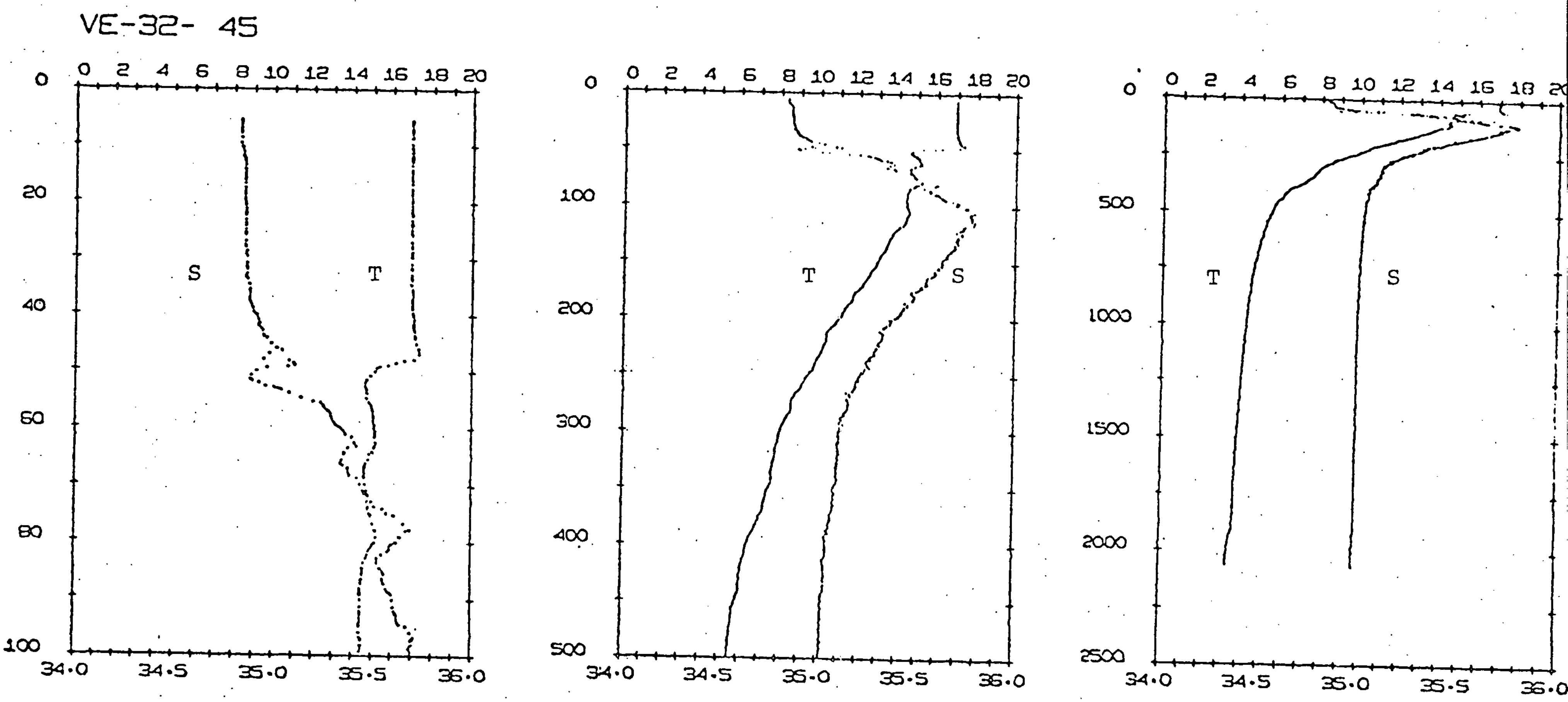


FIGURE 8



VE-32- 45
0 2 4 6 8 10 12 14 16 18 20
0
20
40
60
80
100
S
T
34·0
34·5
35·0
35·5
36·0
0 2 4 6 8 10 12 14 16 18 20
0
100
200
300
400
500
T
S
34·0
34·5
35·0
35·5
36·0
0 2 4 6 8 10 12 14 16 18
0
500
1000
1500
2000
2500
T
S
34·0
34·5
35·0
35·5

FIGURE 9.

VE 32 STA 45 DATE 24 10 74 GMT 1338 LAT 39 27.4N LONG 71 41.5W

CCRR DEPTH 1885M WIND 20 4 SEA 20 4 AIR TEMP 14.8 DEW PT 6.4 BAROM 1024.7

STD 9C40 SAL SENSOR 5312 TEMP SENSOR 5312 DEPTH SENSOR 5312 NO OBS 12

	DEPTH	TEMP	SALIN	DENS	ANOM	DELTA	VELOC	OXYG	PHOS	NITR	SIL	ALK	NO2	AMM
CBS	40		34.968					5.44	0.41	1.8	1.3		1.00	1.27
CBS	382	6.68	35.057	27.53			1484.2	4.27	1.92	23.4	14.0		0.87	1.75
CBS	574		35.009					5.32	1.65	15.9	12.3		0.99	2.32
CBS	760	4.71	34.998	27.73			1482.4	5.68	1.60	19.4	12.0		0.94	1.47
CBS	1277		34.979					6.02	1.60	18.1	11.8		0.83	1.72
CBS	*1509	3.90	34.976	27.80			1491.5	6.12	1.62	19.C	13.8		0.82	1.26
CBS	1705		34.974					6.16	1.60	18.8	13.3		0.78	
CBS	*1843	3.73	34.974	27.81			1496.4	6.16	1.57	18.6	13.3		0.98	1.92
CBS	1946		34.970					6.12	1.54	18.3	14.0		0.78	1.50
CBS	*2C13	3.48	34.968	27.84			1498.3	6.17	1.62	15.6	12.5		0.90	1.30
CBS	2C42		34.967					6.16	1.62	16.9	14.1		0.92	1.23
CBS	2C57	3.43	34.967	27.84			1498.8	6.17	1.51	14.9	12.4		0.74	1.17

	DEPTH	TEMP	SALIN	DENS	ANOM	DELTA	VELOC	INT
STD	0	16.91	34.831	25.42	256.40	0.000	1513.1	6
STC	10	16.91	34.834	25.43	256.45	0.026	1513.2	1
STD	20	16.92	34.854	25.44	255.54	0.C51	1513.5	0
STD	30	16.93	34.863	25.44	255.39	0.C77	1513.7	1
STD	40	17.01	34.9C6	25.46	254.33	0.1C2	1514.1	0
STD	50	15.14	34.919	25.9C	213.03	0.126	1508.6	1
STC	60	15.08	35.339	26.23	181.36	0.145	1509.0	0
STD	70	14.66	35.443	26.41	165.19	0.163	1508.0	1
STD	80	15.15	35.622	26.44	162.77	0.179	1509.9	0
STD	90	14.43	35.606	26.58	149.17	C.195	1507.8	1
STD	1C0	14.43	35.719	26.67	141.32	0.209	1508.1	1
STC	120	14.02	35.734	26.77	132.30	0.237	15C7.1	0
STD	140	13.33	35.668	26.86	123.88	0.262	15C5.1	1
STD	160	12.62	35.592	26.95	116.15	0.286	1502.9	1
STD	180	11.73	35.484	27.03	1C8.11	0.309	1500.1	0
STD	2C0	11.05	35.370	27.07	1C4.58	0.330	1497.9	1
STD	225	10.24	35.294	27.16	96.82	0.355	1495.3	1
STD	250	9.49	35.209	27.22	91.11	0.379	1492.9	1
STD	275	8.63	35.151	27.31	82.33	0.4C0	149C.0	1
STD	3C0	8.08	35.1C6	27.37	77.64	0.420	1488.3	1
STD	350	7.51	35.078	27.43	72.30	0.458	1486.9	1
STD	4C0	6.45	35.C42	27.55	60.83	C.491	1483.5	1
STD	450	5.87	35.C27	27.61	54.97	0.520	1482.0	1
STC	5C0	5.53	35.020	27.65	51.86	0.547	1481.4	1
STC	550	5.28	35.013	27.67	49.82	0.572	1481.2	1
STC	6C0	5.13	35.010	27.69	48.73	0.597	1481.4	1
STC	650	4.94	35.006	27.71	47.21	C.621	1481.5	0
STC	7C0	4.81	35.C03	27.72	46.44	0.644	1481.7	1
STD	750	4.68	35.000	27.73	45.59	0.667	1482.0	1
STD	800	4.57	34.995	27.74	45.16	0.690	1482.4	1
STD	850	4.51	34.997	27.75	44.86	0.712	1483.0	1
STD	9C0	4.42	34.994	27.76	44.49	0.735	1483.5	1
STD	950	4.37	34.993	27.76	44.39	0.757	1484.1	1
STD	1CC0	4.32	34.992	27.77	44.38	C.779	1484.7	1
S.D	1100	4.22	34.989	27.78	44.24	0.823	1485.9	2
STC	12C0	4.13	34.989	27.78	44.18	0.868	1487.2	0
STD	1300	4.04	34.986	27.79	44.06	C.912	1488.5	1
STD	1400	3.98	34.986	27.80	44.23	0.956	1489.9	1
STD	15C0	3.9C	34.986	27.81	44.17	1.CC0	1491.3	1
STC	16C0	3.84	34.985	27.81	44.24	1.C44	1492.7	1
STD	1700	3.76	34.984	27.82	44.21	1.088	1494.1	1
STD	1800	3.76	34.985	27.82	44.91	1.133	1495.7	0
STC	19C0	3.71	34.984	27.82	45.18	1.178	1497.2	0
STD	20C0	3.48	34.977	27.84	43.39	1.222	1498.0	1
STD	2C65	3.45	34.976	27.84	43.56	1.251	1498.9	0

BCTTCM CEPTH= 2065M

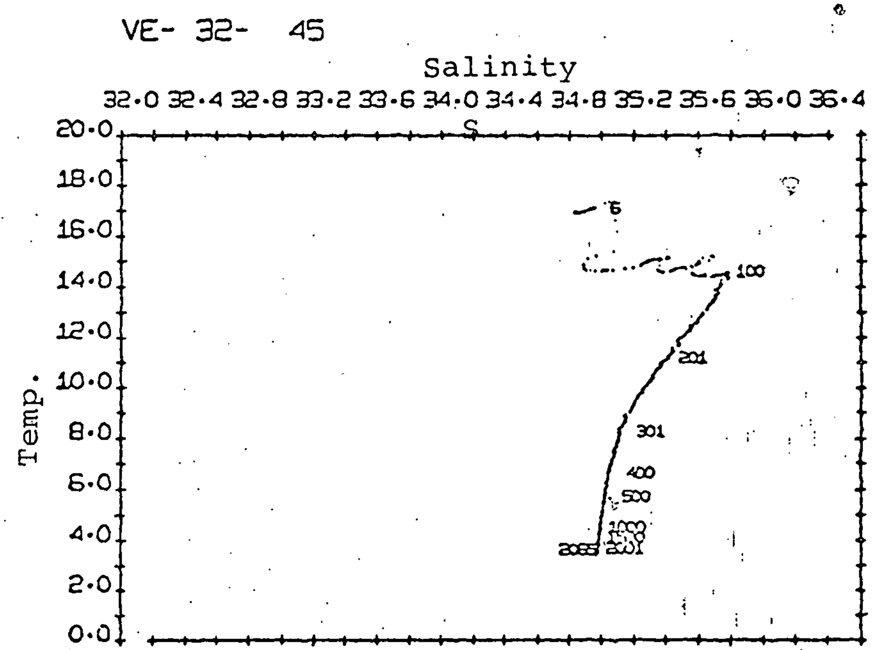


FIGURE 10.

8.2 Nephelometry

8.2.1 Explanation of Plots

The optical density of the film is measured using a Photovolt photodensitometer system with a Bausch & Lomb recorder. Discrete measurements are made at predetermined points along the film of the two scattered light images and three direct light images. These are called cross-run measurements. The sensitometer patch is measured with this instrument and from this the characteristic curve relating optical density to log exposure (log E) is obtained. The direct light log E_D is substracted from the average scattered light log E and a correction added to make the measurement comparable to the Lamont standard nephelometer (Figure 11).

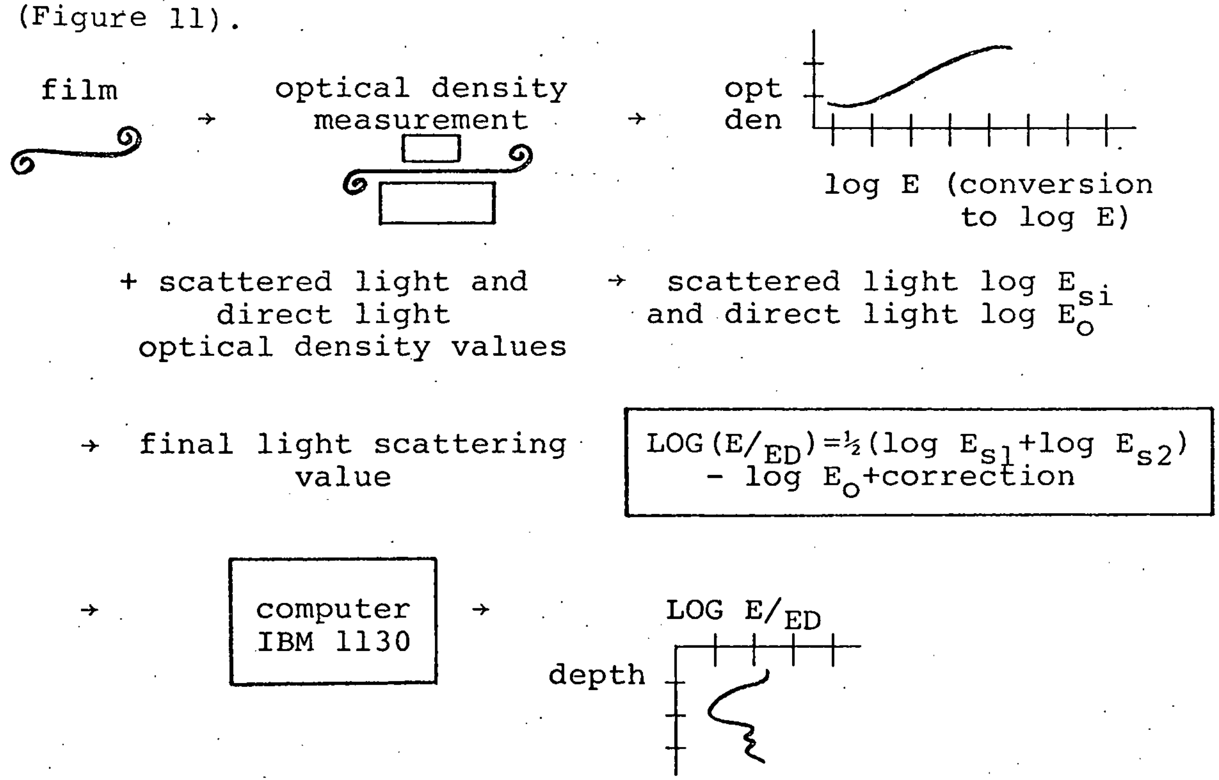


FIGURE 11. SCHEMATIC OF NEPHELOMETER DATA REDUCTION TECHNIQUES.

where $\log E_{si}$ is the log exposure of the scattered light image and $\log E_o$ is the log exposure of the direct light image. The correction depends on which of the three direct-light images is used and which instrument is used. The usual technique of utilizing the pressure transducer to obtain depth was only used on the camera/nephelometer stations. A more accurate method of using STD depths, when the nephelometer was attached to the STD wire was employed for these profiles.

Scott Daubin, Jr. has developed a data reduction technique to produce the nephelometer profiles presented here. A detailed digitization was made of the analog record of optical densities between cross-run values. This gives a continuous light-scattering trace, adjusted to the cross-run points that is more suitable for comparison with the STD traces. Figure 12 is an example of the final output using this technique. The down- and up-traces are shown as solid and dotted lines, respectively. Down-trace cross-run measurements are indicated by squares, up-trace measurements by circles. The corrected PDR depth is shown as a hatched line. The clearest water levels are indicated by triangles along the left-hand depth axis (down-trace triange facing right, up-trace triangle facing left). The agreement between these values and cross-run values taken later as checks is generally ±5%, which is within the acceptable error limits for this instrument.

8.2.2 Sample Nephelometer Data

A sample of the nephelometer trace data is presented in Figure 12.

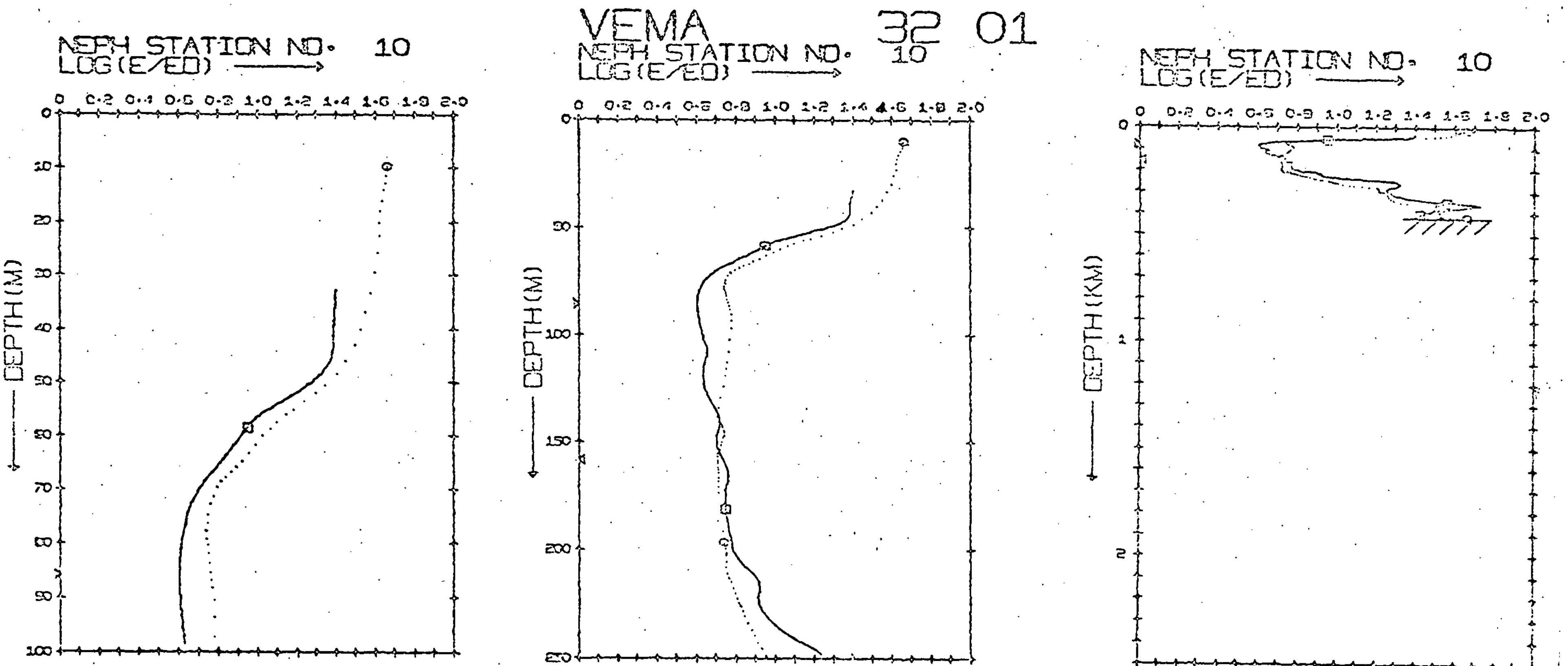


FIGURE 12. NEPHELOMETER #10 PROFILE PLOTTED ON 0-100, 0-250 and 0-2500 m SCALES.

COMPLETE EXPLANATION IN TEXT.

8.3 Bottom Photography

8.3.1 Sample Bottom Photographs (Figure 13)

8.4 Hudson Canyon Currents & Light-Scattering

8.4.1 Explanation of Plots

For the 53-day record of currents, east and north components are plotted as a function of time (Figure 14) and a speed histogram, vector rose and statistical data are also given (Figure 15).

The nephelometer data is plotted as a function of time. The vertical scale is log (e/e_D), the log of the ratio of scattered light to direct light, similar to that used for the nephelometer profiles in section 8.2.2.

8.4.2 Sample Current Data (Figures 14, 15)

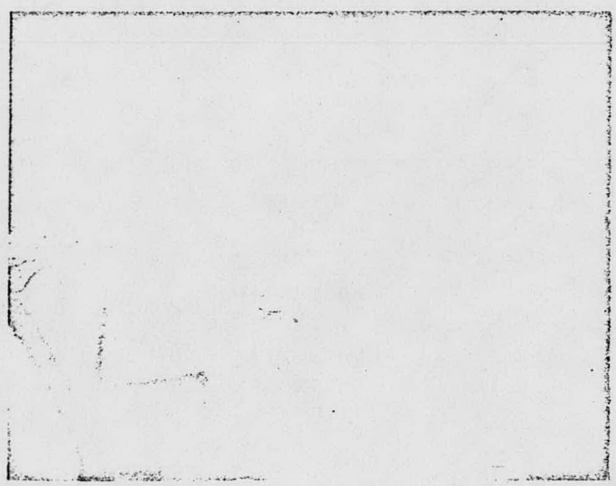
8.4.3 Sample Light-Scattering Data (Figure 16)

FIGURE 13.

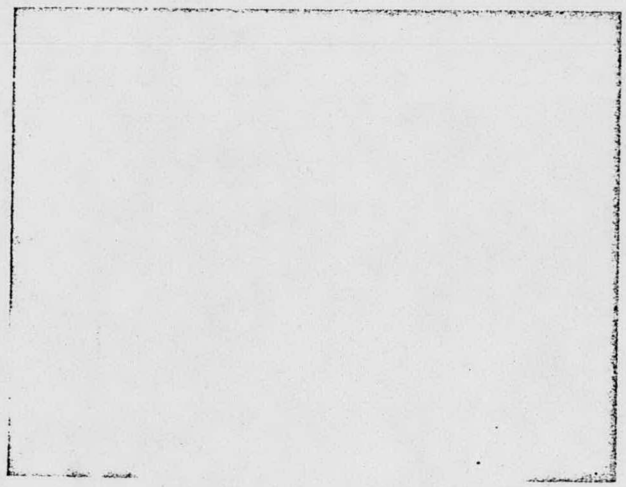
BOTTOM PHOTOGRAPHS FROM V-32 CAMERA
STATION #7.

K 7-1

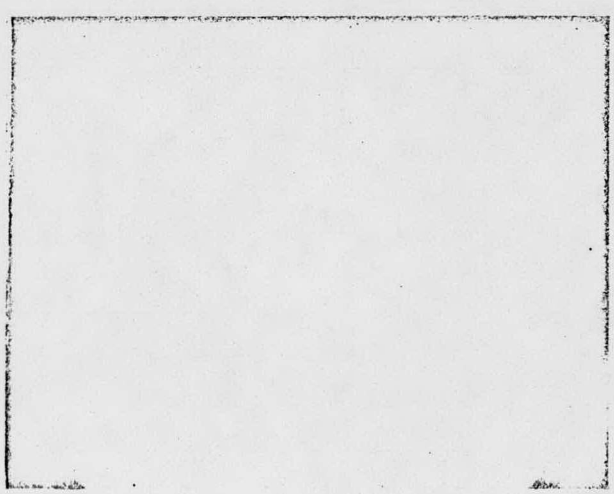
K 7-2



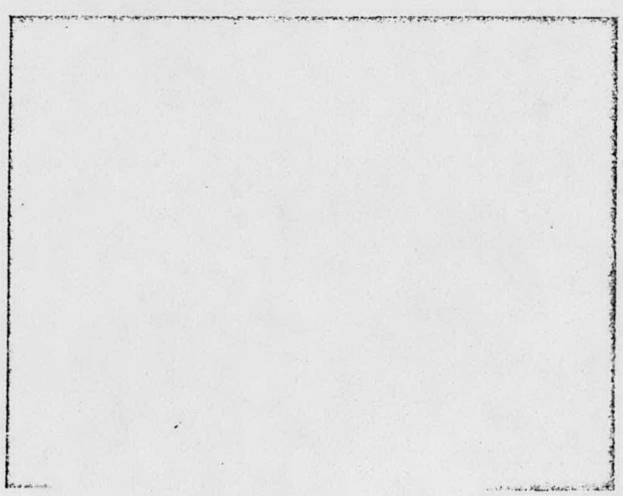
K 7-3



K 7-4



K 7-5



K 7-6

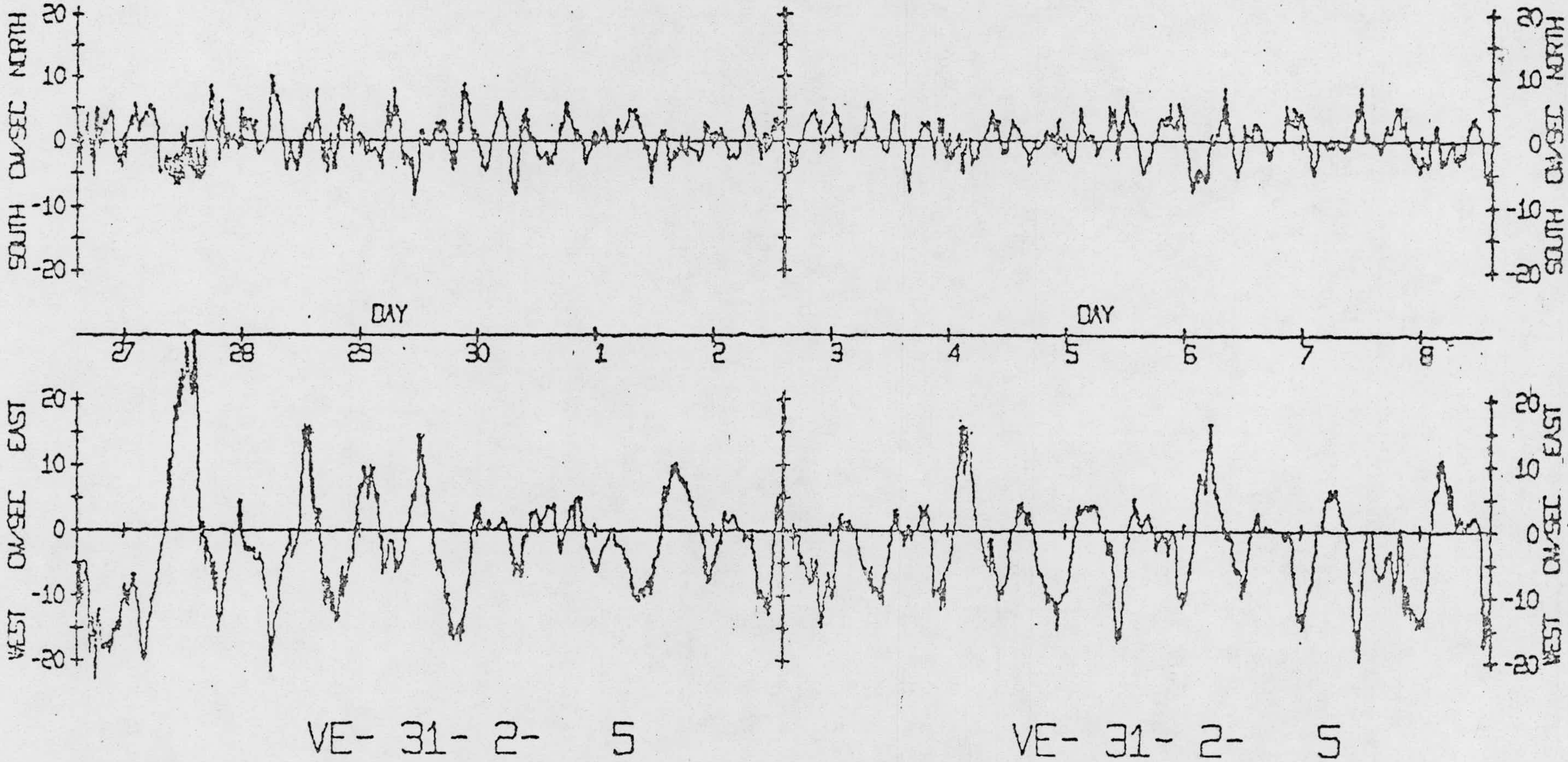


FIGURE 14. NORTH (TOP TRACE) AND EAST (BOTTOM TRACE) COMPONENTS OF THE CURRENTS 5 m ABOVE THE HUDSON CANYON FLOOR AT A DEPTH OF 827 m. RECORD SPANS 27 September - 8 October, 1974.

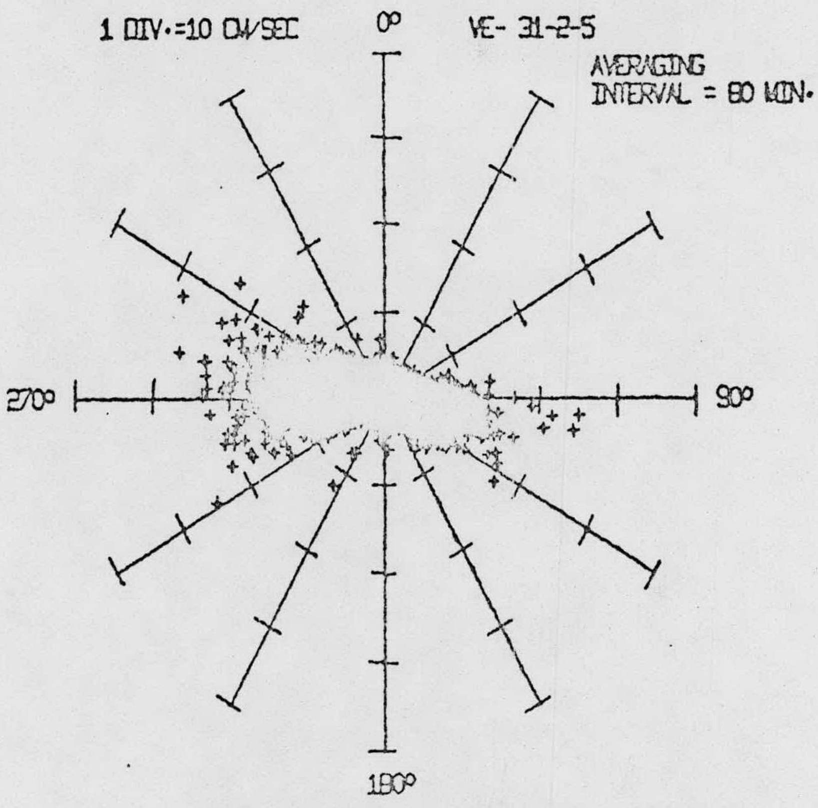
FIGURE 15. SPEED HISTOGRAM, VECTOR DISTRIBUTION ROSE AND STATISTICAL DATA OF CURRENT RECORD IN HUDSON CANYON FROM September 2, 1974 to October 25, 1974.

SPEED HISTOGRAM

VE-31- 2- 5

CM/SEC	FREQ.
0.5	1067
1.5	312
2.5	697
3.5	724
4.5	609
5.5	444
6.5	586
7.5	410
8.5	432
9.5	393
10.5	353
11.5	213
12.5	217
13.5	184
14.5	150
15.5	141
16.5	148
17.5	95
18.5	87
19.5	65
20.5	76
21.5	50
22.5	48
23.5	37
24.5	24
25.5	14
26.5	15
27.5	5
28.5	7
29.5	4
30.5	2
31.5	2
32.5	1

NO. OF PTS. OUTSIDE SPEED RANGE = 4



VECTOR DISTRIBUTION

********* STATISTICS *********

NO. OF DATA POINTS= 7616
(RAW DATA UNITS - CM/SEC,DEGREES)

---- EAST-WEST ----

MEAN =	-2.78
STD. ERROR OF MEAN =	0.09
VARIANCE =	66.74
STD. DEVIATION =	8.16
KURTOSIS =	5.27
SKEWNESS =	-0.27

--- NORTH-SOUTH ---

MEAN =	0.22
STD. ERROR OF MEAN =	0.03
VARIANCE =	11.37
STD. DEVIATION =	3.37
KURTOSIS =	55.18
SKEWNESS =	-0.97

------ SCALAR -----

MEAN =	7.05
STD. ERROR OF MEAN =	0.06
VARIANCE =	36.16
STD. DEVIATION =	6.01
KURTOSIS =	18.34
SKEWNESS =	1.94

--- CO-VARIABLE ---

COVARIANCE =	-6.58
STD. ERROR OF COVARIANCE =	2.56
STD. DEVIATION OF COVARIANCE =	0.02
CORRELATION COEF.=	-0.23

------ VECTOR -----

MEAN VECTOR =	2.77
VARIANCE =	39.06
STD. DEVIATION =	6.25
DIRECTION =	275
DIRECTION DEV.=	82.48

FIGURE 16. CONTINUOUS RECORD OF LIGHT-SCATTERING 9 M ABOVE HUDSON CANYON FLOOR AT A DEPTH OF 827 m. RECORD SPANS 27 September - 8 October, 1974. THE LEFT-HAND ORDINATE IS Δ NEPHS = DIFFERENCES ABOUT THE MEAN FOR THE ENTIRE RECORD. RIGHT-HAND ORDINATE IS THE ABSOLUTE VALUE OF LIGHT SCATTERING. BOTH ORDINATES ARE Log(E/E_D) - EXPLAINED IN TEXT.