NORTH ATLANTIC OCS ENVIRONMENTAL

ASSESSMENT

2nd Quarterly Progress Report

for the period

January 1, 1977 - March 31, 1977

A Report to the Bureau of Land Management

U.S. Geological Survey
Office of Marine Geology
Woods Hole, Massachusetts 02543
18 April 1977

CONTENTS

Summary Statement

D.W. Folger

One tripod set in December on the south flank of Georges Bank was recovered intact; all systems apparently functioned properly and data acquired are being processed. The tripod set in Great South Channel near the ARGO MERCHANT was recovered on April 16 but tapes and film have not been reviewed as yet.

Laboratory analyses in all other areas are proceeding.

Cooperation with ERCO has been excellent. Seston and transmissometer data acquired on the first cruise appears to be of high quality and analyses of them are in process.

Data management updates have been provided to Raytheon on schedule.

A preliminary summary of the geologic hazards on Georges Bank is included below. Also included as Appendix I is the text of North Atlantic Environmental Geologic Studies written in accordance with a format determined by the conveners of a conference concerning BLM studies that was held at the University of Rhode Island on April 4, 1977.

Preliminary Summary of

Geologic Hazards on Georges Bank

D. W. Folger

USGS, Woods Hole, MA 02543

Water Column.

Current meter measurements at four locations indicate that a clockwise gyre exists over the Bank with a mean flow that is particularly strong (30 cm/sec) in the north side (see 1st Quarterly Report). Tidal currents flow with speeds up to 2 knots at mid-water depths and higher values near surface. The mean flow plus the strong tidal flow could distribute pollutants entrained in the water column widely over the Bank surface, regardless of their point of injection within the 100 m isobath.

Turbidity increases in the water column mainly during plankton blooms and when water motion due to waves and currents resuspends bottom sediment. Natural background concentrations of total suspended matter on the Bank range up to about 2.0 mg/1 and most often are less, but a layer of organic-rich suspended matter was observed in July, 1976 between 40-55 m deep in the water column where concentrations ranged up to 3 mg/1. Presumably, the particulate matter making up this and similar nepheloid (turbid) layers might serve as a host for and enhance settling of oil spilled in the area. Most risk of oil scavenging by terrigenous particulates will probably occur during major storms when resuspension of bottom sediment is extensive even in water 85 m deep.

Bottom.

Bottom sediment mobility is widespread throughout the area in response to tidal currents, waves, and storm-driven currents. Other forcing mechanisms, such as internal waves may account for some of this mobility. Most vigorous sediment motion appears to occur at shallow depths, probably $<$50 m except in areas where flow is restricted, such as in Great South Channel. Sand waves range from large shoals several km in wave length to second order features, commonly several 100 meters in wave lenght and 10-20 m high that are in motion. Smaller asymmetric ripples present (10 cm wave length) move in response to currents and waves even near the shelf edge. Thus, scour will be a problem over much of the Bank; but it will be most severe at shallow depths. The Texas Towers erected on Nantucket Shoals and on the north flank of the Bank reportedly were dismantled because scour around the legs weakened the structures. Observers on one of the towers reported one wave about 20 m in height and water flowing, during the hurricane, at a speed of 20 knots. (The latter phenomenon, if true, may have been due in part to wave surge.) Pipelines would have to be limited to deep water routes and would have to be buried below the mobile surficial layer. Because of common gravel and boulders on the bottom and the high tidal currents, this will constitute a significant engineering problem.

Subbottom.

Borings on the north side of the Bank and on Nantucket Shoals were carried out to a maximum depth of 63 m prior to the construction of two Texas Towers. Several of the holes penetrated silty, clayey layers up to 15 m thick. Similar fine textured sediments have been recovered in vibrocores recently recovered from Nantucket Shoals. These sediments may be widespread over the entire Bank and clearly may constitute a hazard to the stability of any structures constructed on them.

High resolution seismic data thus far does not reveal any shallow faults, at least within the limit of equipment resolution. However, the records do contain acoustic evidence of several episodes of channel cutting and filling, especially within the upper 20-80 m of sediment. The probable varied texture of the uppermost strata may provide an unstable foundation for structures erected on it. Data must be acquired to assess the geotechnical properties of these materials.

In summary, the principle hazards to petroleum development include: (1) The high current speeds associated with tides and storms; (2) The potential of suspended matter to scavenge spilled oil and other pollutants and to transport them to the bottom where they may interfere with the rich benthic community; (3) Bottom sediment mobility, due to sediment resuspension and sand wave migration, that poses a threat to structures mounted on legs or buried below the bottom; and (4) The potential instability of the materials in the upper 20-80 m that have not yet been assessed for such geotechnical properties as bearing capacity.

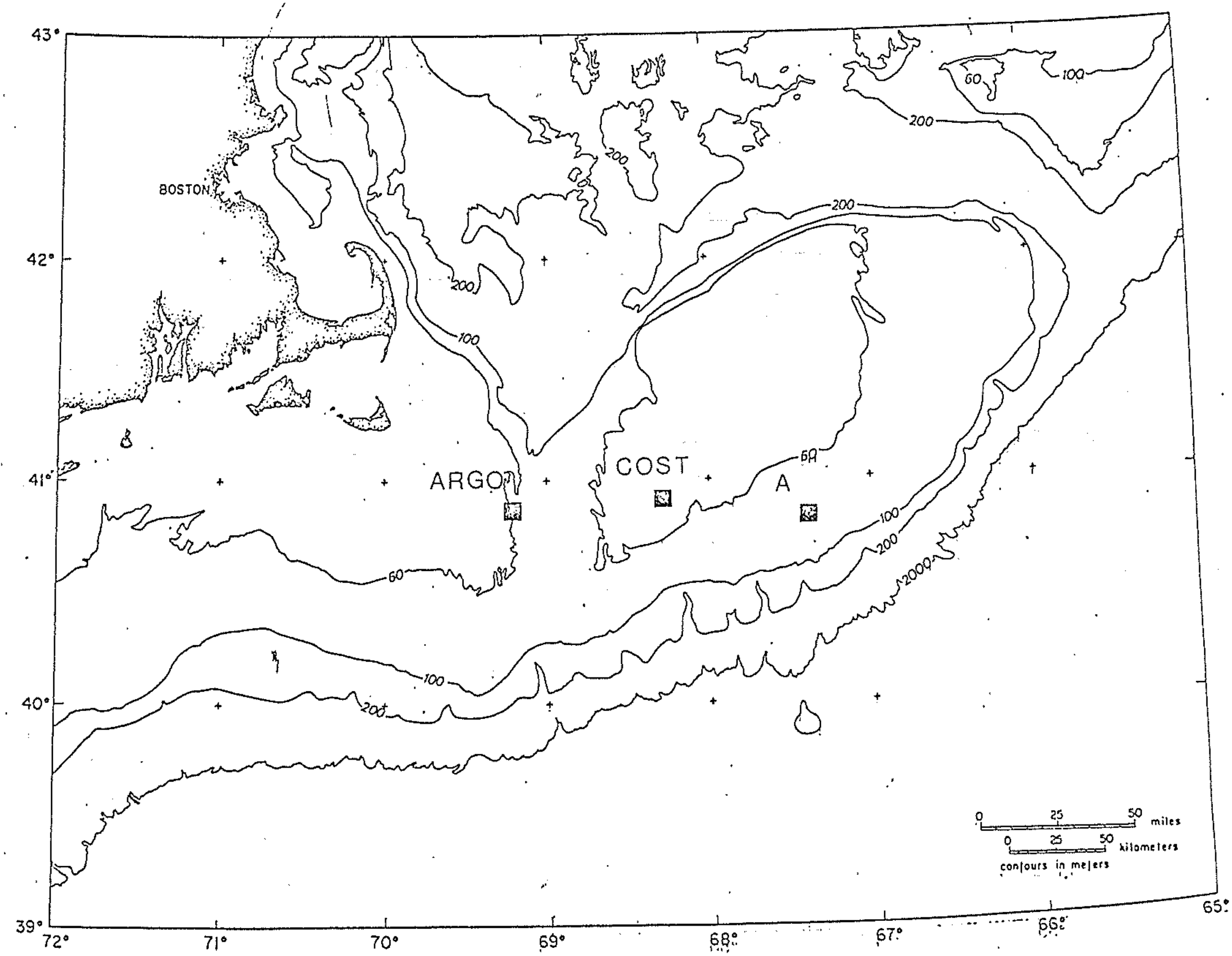
Because of the vigorous water circulation patterns around the Bank, stringent precautions are essential to avoid spills that could severely degrade the rich biologic community. Lease areas that lie in water <50 m deep should be considered as particularly hazardous and appropriate precautions exercised to minimize risk of structural failures. Similarly, further studies of the bearing capacity of the subbottom material must be carried out before platforms or pipelines are constructed.

Sediment Transport

B. Butman, D. Folger, M. Noble

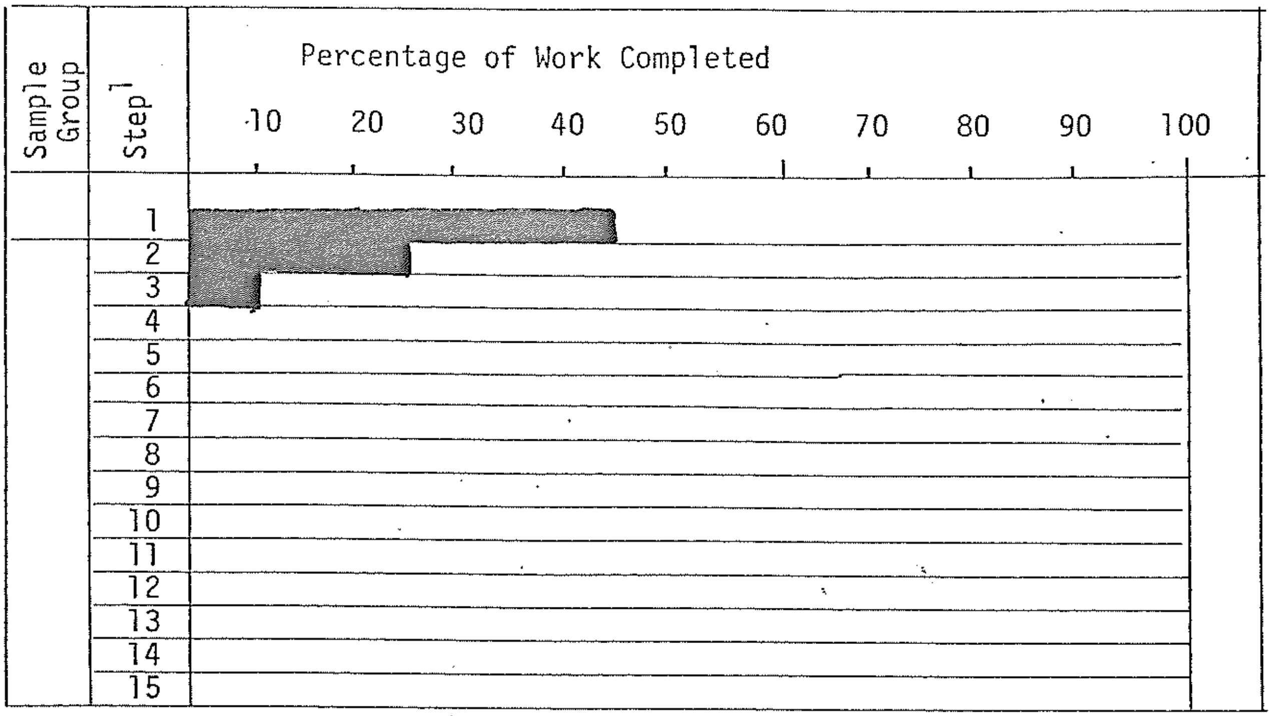
USGS field work during the 2nd Quarter included the recovery of two tripods and the deployment of one. The tripod deployed in December on the south flank of Georges Bank (Station A) (Fig. 1) was recovered on 18 March. All systems appear to have operated successfully and photos and data are now being analyzed. An initial scan of the data indicates that ripples form and are destroyed even in waters 85 m deep in response to strong tidal flow and storm-driven currents. Turbidity increases in response to these same forcing mechanisms.

The tripod deployed near the ARGO MERCHANT (Fig. 1) was recovered on 16 April. All sensors were in place but tapes and film have not been processed as yet to determine the extent of data collected.



Georges Bank
USGS Tripod Deployment

Sediment Transport



1. Data Collected
2. Data Analyzed
3. Data Synthesized
4. Data Compiled

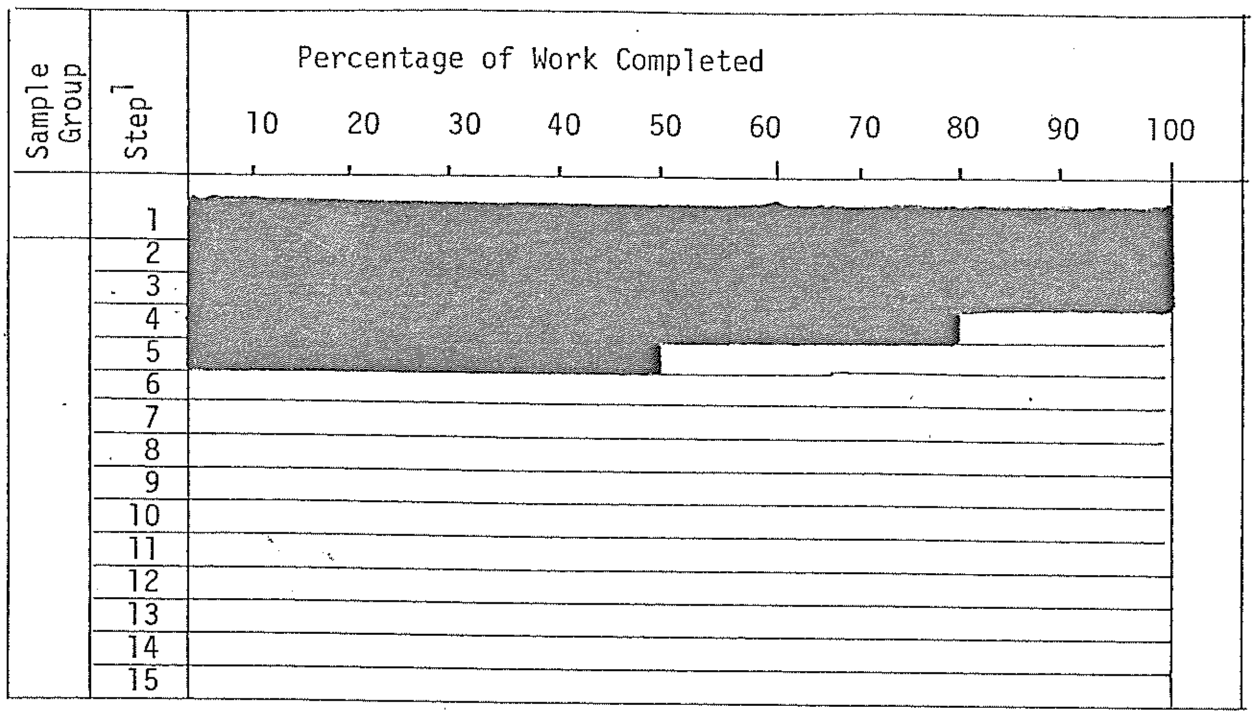
Submersible Observations

D.W. Folger, B. Butman, M. Bothner

Integration of data is proceeding and synthesis with other observations is about 50% complete.

Submersible Observations

Progress Chart



1. Data Collection
2. Photograph Analyses
3. Grab Sample Analyses
4. Integration of Sediment Data and Visual Observations
5. Synthesis

Seston and Turbidity Measurements

J. Milliman and M. Bothner

From December through February, a total of nearly 180 samples from 70 stations were collected from the Georges Bank area. The first cruise, OCEANUS 17 in early December, 1977, was in conjunction with the collection and deployment of current meter buoys throughout the area. During this cruise, 20 stations were occupied with a total of 60 samples taken; another 7 stations were occupied where 21 samples were taken to the south in the Middle Atlantic region. These samples have been analyzed for total particulates, organics, optical and chemical qualities. Only organic carbon/ nitrogen values still need to be measured.

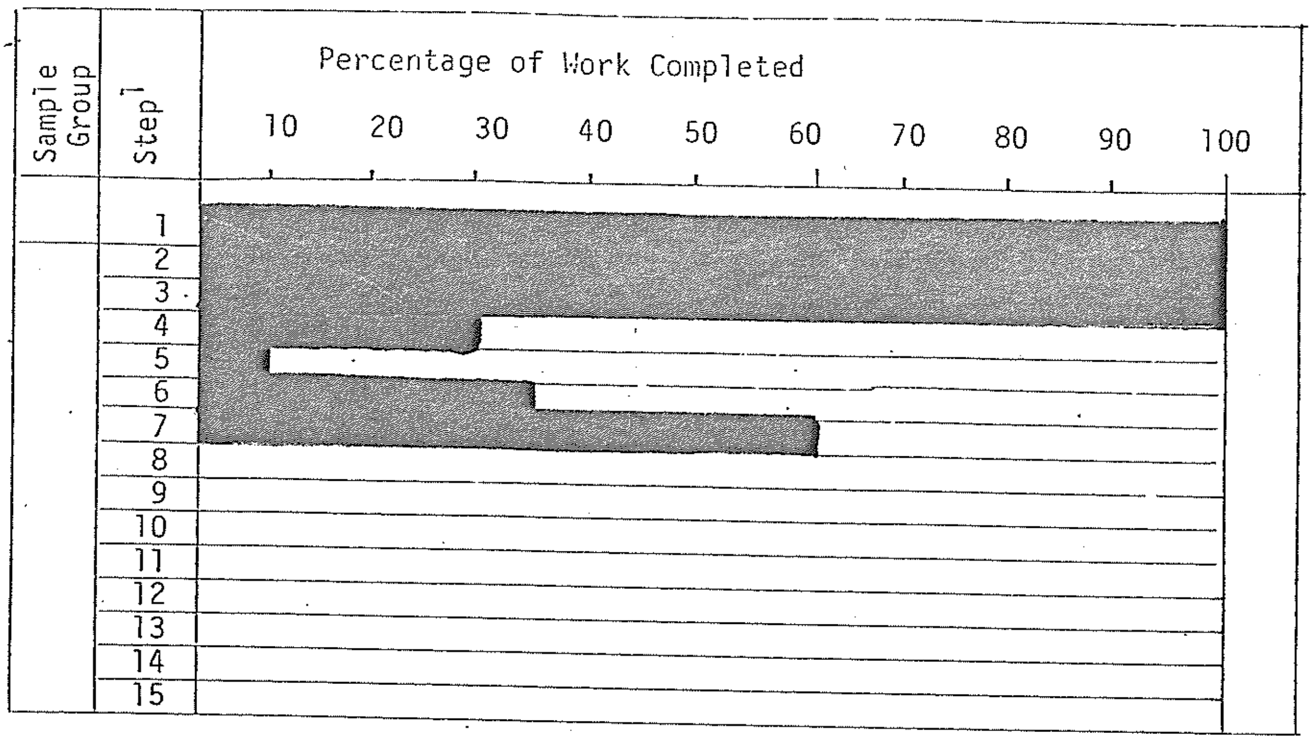
Two unscheduled cruises occurred in late December as a result of the ARGO MERCHANT oil spill. On the first cruise, OCEANUS 19, 9 suspended matter samples were taken at 3 stations (adverse weather conditions forced termination of the cruise). On the second cruise, 8 stations were occupied and 24 samples collected. These samples have been analyzed for all parameters except organic carbon and nitrogen.

The last cruise during this period was the first ERCO cruise, February 11-March 6, during which 39 stations were occupied and 114 samples collected. Thus far, these samples have been analyzed for total particulates, but other analyses have not been carried out.

The Montedoro-Whitney Deck Read-Out has just been received from Larry Doyle who needed it for the South Atlantic cruises. Analyses of transmissometer tapes is once again proceeding on North Atlantic tapes. Because the Deck Read-Out will soon be at sea on a Mid-Atlantic cruise, tape analyses will again cease. As noted in the Mid-Atlantic Quarterly Progress Report, another Deck-Read Out is needed.

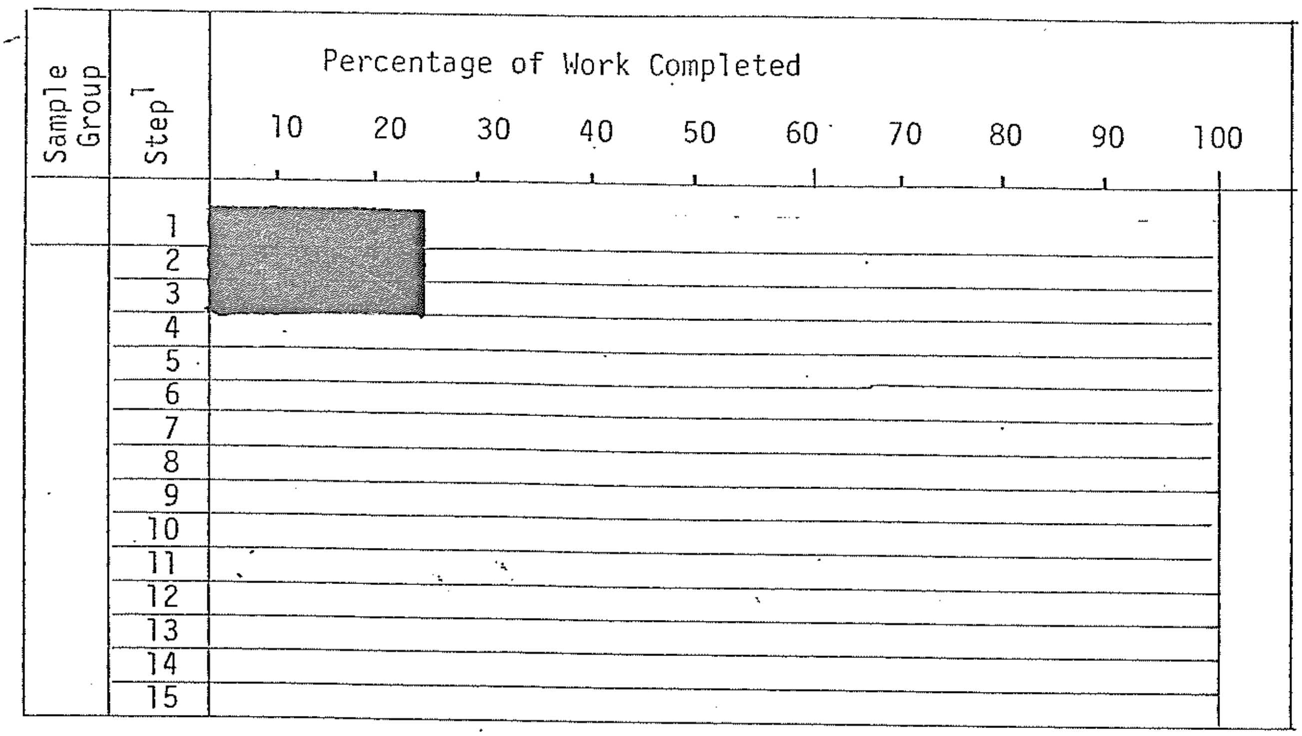
Initial review of real time transmissometer records received from ERCO indicates that the data are of very good quality.

USGS SESTON SAMPLES



1. Sample Collection
2. Total Particulate Concentrations
3. Combustible and non-combustible concentrations
4. Optical Study of Particulates
5. SEM Study of Particulates
6. Organic C/W Analyses
7. Chlorophyll Analyses
8. Synthesis of Data
9. Compilation
10. Integration with other data

ERCO Seston Samples



1. Sample Collection
2. Total Particulate Concentrations
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9. Compilation
10. Integration with other data

Texture and Mineralogy

M. Bothner, R. Fabro, P. Johnson, S. Wood

Clay mineralogy has been run on 2 samples from each core. The results are shown in Table 1. Thus, textural and mineralogical analyses of the vibracores are now complete.

Table 1 Composition of Vibracores and Hydrostatically Damped Gravity Cores

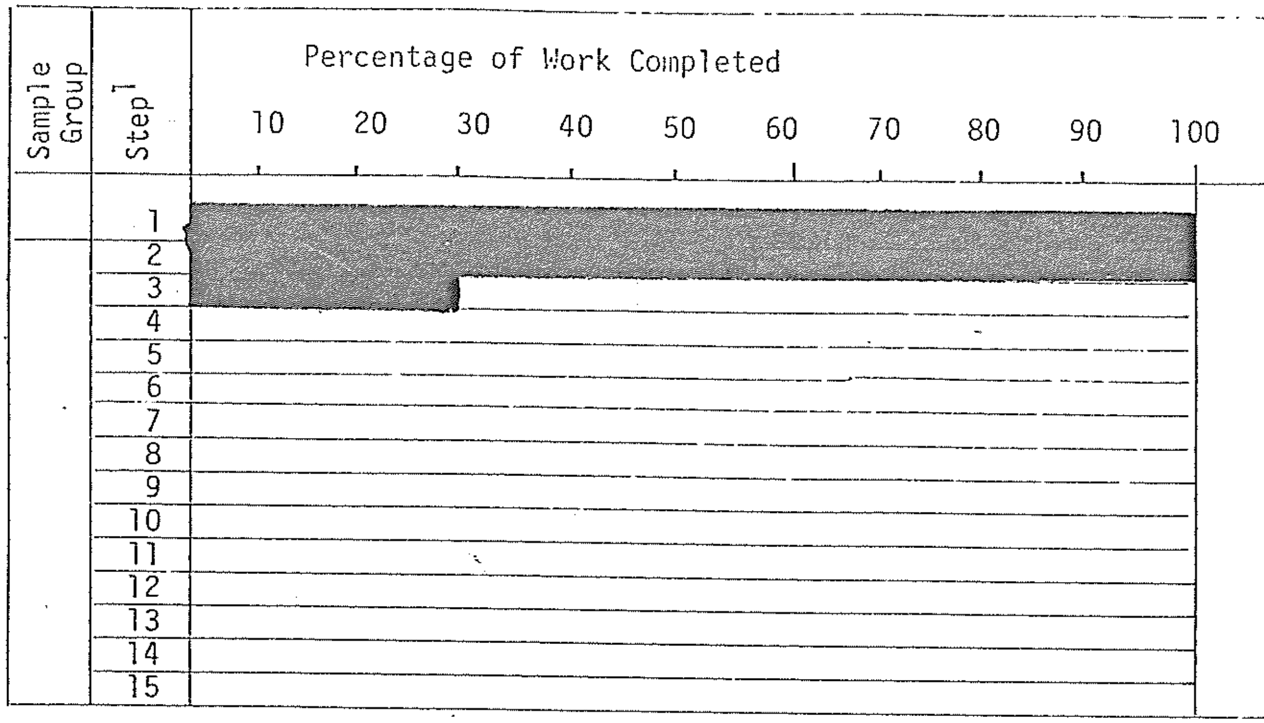
Sample Number \ Minerals	Mica	Smectite	Mixed Layer	Kaolinite	Chlorite/Kao	Glauconite	Other Clay	Quartz	Feldspar	Pyrite	Calcite	Halite	Other Min.	Comments
4500 1-90cm	✓				✓		✓	✓						NON-SWELLING CLAYS PRESENT; unidentified 8.40 peak
4500 2-50cm	✓		✓		✓			✓	✓				✓	Siderite, unidentified 8.40 peak
4505 2-137cm	✓				✓		?✓	✓						POSSIBLE NON-SWELLING CLAYS PRESENT
4505 3-26cm	✓		✓		✓			✓	✓				✓	Siderite
4507 9cm	✓		✓		✓			✓	✓			✓	✓	Siderite
4507 13.5cm	✓				✓		✓	✓	✓					NON-SWELLING CLAYS PRESENT
4507 1-25cm	✓	✓			✓		✓	✓	✓					NON-SWELLING CLAYS PRESENT
4507 3-28cm	✓	✓			✓		✓	✓	✓			✓		NON-SWELLING CLAYS PRESENT
4508 12cm	✓		✓		✓			✓	✓				✓	Siderite TR, unidentified 8.40 peak
4508 17.5cm	✓		✓		✓		✓	✓	✓		?✓		✓	NON-SWELLING CLAYS PRESENT; Siderite TR
4508 1-124cm	✓	✓	✓		✓		✓	✓	✓			✓	✓	NON-SWELLING CLAYS PRESENT; Siderite TR, Amphibole
4508 2-31cm	✓		✓		✓		✓	✓	✓			✓	✓	NON-SWELLING CLAYS PRESENT; Siderite
4509 1-96cm	✓		✓		✓			✓	✓				✓	Siderite, possible zeolite at 6.30.
4509 1-138cm	✓	✓			✓		✓	✓	✓				✓	NON-SWELLING CLAYS PRESENT; Siderite TR, unidentified 8.4
4510 1-140cm	✓	✓	✓		✓			✓	✓			✓	✓	Siderite
4510 1-148cm	✓		✓		✓			✓	✓		?✓	✓	✓	Siderite, unidentified 8.40 peak.
4514 1-30cm	✓	✓	✓		✓		✓	✓	✓			✓	?✓	NON-SWELLING CLAY MINERAL; Siderite TR(?)
4514 1-96cm	✓	✓	✓		✓		✓	✓	✓		✓	✓	✓	NON-SWELLING CLAYS PRESENT; Siderite TR, Amphibole.
4515 1-33cm	✓	✓	✓		✓		✓	✓	✓				✓	NON-SWELLING CLAYS PRESENT; Siderite
4515 1-133cm	✓	✓	✓		✓			✓	✓		✓		✓	Siderite, unidentified 8.40 peak.
4518 1-129cm	✓	✓			✓			✓	✓			✓		unidentified 8.40 peak.
4518 2-19cm	✓	✓			✓			✓	✓				✓	Siderite
4521 1-81cm	✓				✓		✓	✓	✓				✓	NON-SWELLING CLAYS PRESENT; Siderite, unidentified 8.4
4521 2-35cm	✓				✓		✓	✓	✓			?✓	✓	NON-SWELLING CLAYS PRESENT; Siderite, unidentified 8.40
4525 1-99cm	✓		✓		✓		✓	✓	✓			✓		NON-SWELLING CLAYS PRESENT
4525 1-123cm	✓		✓		✓		✓	✓	✓				✓	NON-SWELLING CLAYS PRESENT; Siderite, unidentified 8.?

Table 1 (con't)

Sample Number \ Minerals	Mica	Smectite	Mixed Layer Sp.	Kaolinite	Chlorite/Kaolinite	Glauconite	Other Clay	Quartz	Feldspar	Pyrite	Calcite	Halite	Other Min.	Comments
4526 2-107cm	✓	✓	✓		✓			✓	✓			✓	✓	Siderite
4526 4-35cm	✓		✓		✓			✓	✓			✓	✓	Siderite, unidentified 8.40 peak.
4527 1-100cm	✓				✓		✓	✓	✓		✓	✓	✓	NON-SWELLING CLAY MINERAL | Siderite, unidentified 8.40 pe
4527 4-75cm	✓	✓	✓		✓			✓	✓		✓		✓	Siderite TR

8.40 peak usually associated wi
Amphiboles, showed up intermi
ly in these samples. When ot
peaks of Amphibole were also f
then Amphibole was listed.
However, the 8.40 peak frequentl
occured with no Secondary peaks
and only showed up under differen
treatments on the samples; it w
then listed "unidentified 8.40 pe

TEXTURE AND MINERALOGY



1. Collection of samples
2. Laboratory Analyses
3. Synthesis of data
4. Intergration with other observations
5. Compilation

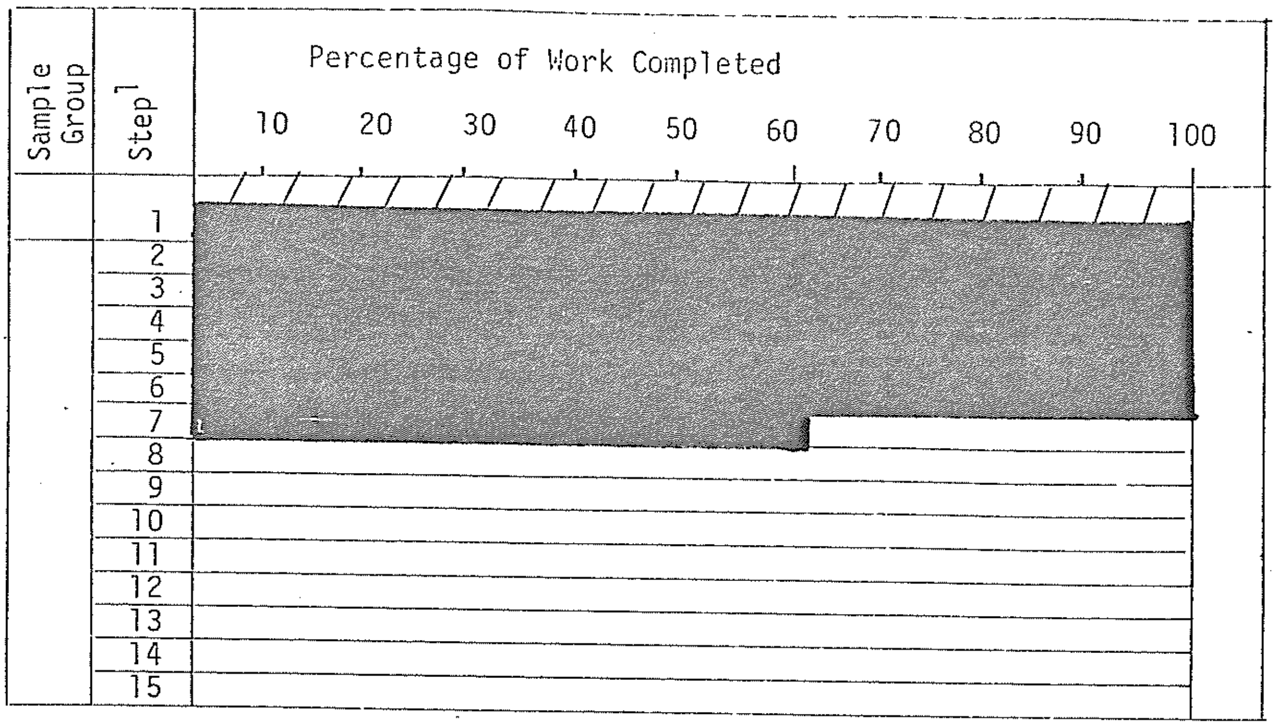
Vertical Distribution of Trace Metals and Texture in Sediments of Georges Bank

Michael H. Bothner and Randy J. Fabro

All anlayses are complete and the synthesis of data is proceeding.

VERTICAL DISTRIBUTION OF TRACE METALS AND

TEXTURE IN SEDIMENTS OF GEORGES BANK



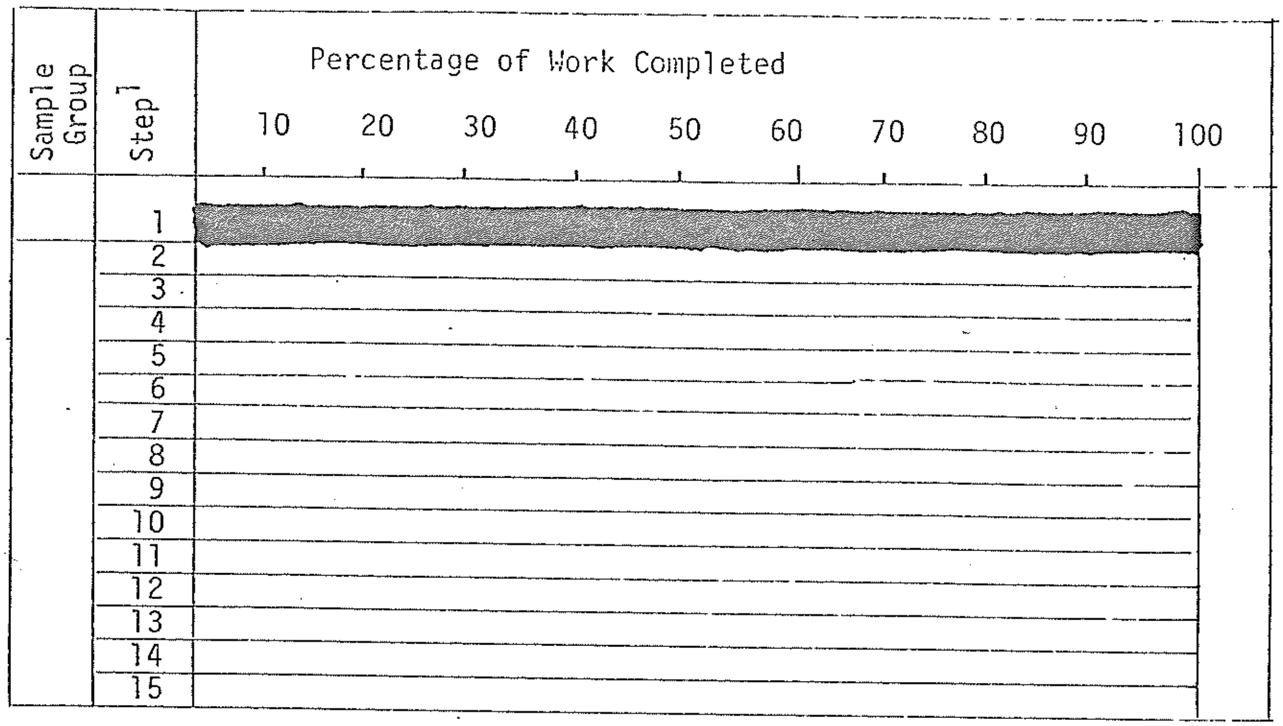
1. Cores collected
2. Cores described and subsampled
3. Analysis of grain size
4. Analysis of trace metals
5. Analysis of organic carbon in selected samples
6. Data tabulated
7. Synthesis

Carbon 14 Dates

D.W. Folger

Cores have not yet been sampled for Carbon 14 measurements.

CARBON 14 DATES



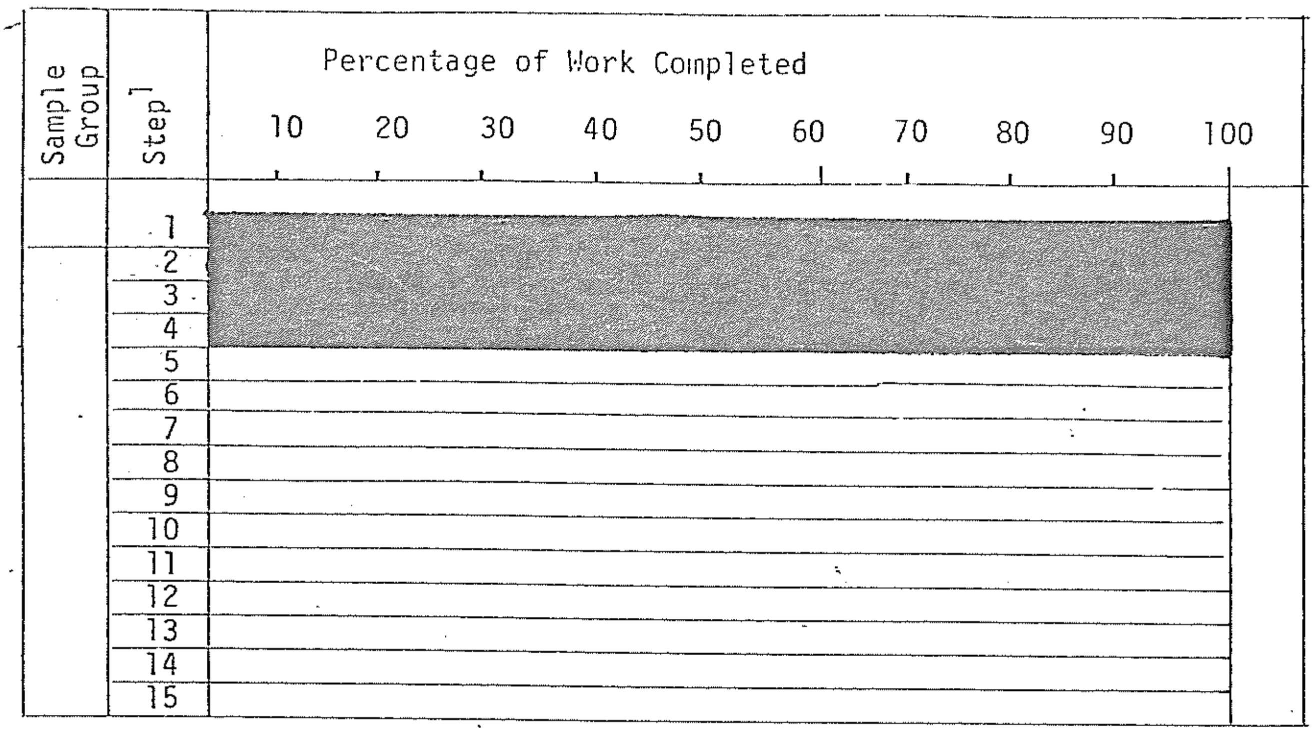
1. Cores collected
2. Cores sampled
3. Samples shipped to Reston
4. Analyses completed
5. Data compiled
6. Results intergrated with other sediment data

Tectonic Hazards

R.E. Sylwester

The first year study is complete.

TECTONIC HAZARDS



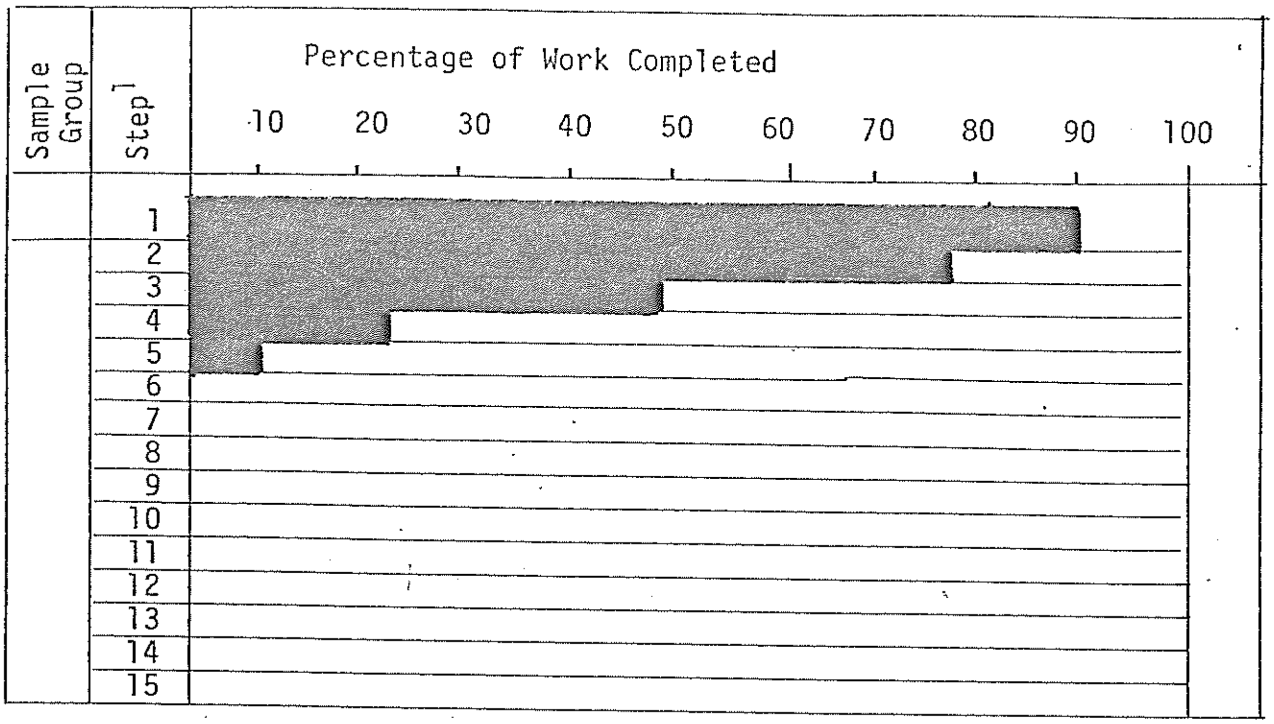
1. Data collection
2. Data reduction
3. Synthesis
4. Compilation

Water Mass Transport

B. Butman, R.C. Beardsley, J. Vermersch

Analysis of current meter data acquired from meters recovered in December from the south flank of Georges Bank is proceeding. A preliminary assessment indicates that the information acquired is of high quality. Current meter data will be integrated with wind data from shore stations as soon as they are received.

Water Mass Transport



1. Data Collection
2. Preliminary Processing
3. Data Analysis
4. Data Synthesis
5. Data Compilation

Appendix I

North Atlantic OCS Environmental Assessment
Geologic Studies
D. W. Folger
USGS, Woods Hole, MA 02543

Problem

Comprehensive studies of the hydrography and geology of Georges Bank that are pertinent to environmental problems have been sparse. Bumpus (1973) outlined the residual circulation in the area mainly on the basis of bottom and surface drifter recoveries. Csanady (1974) attempted to explain the observed current pattern in a winddriven circulation model. Sand wave character and movement were discussed by Jordan (1964) and physiography mapped by Uchupi (1968). About 200 grab samples were collected by USGS and analyzed for texture and chemistry (Hathaway, 1971). A few high resolution profiles were acquired by Knott and Hoskins (1968). Sixteen holes up to 60 m deep were drilled on Nantucket Shoals and Georges Bank prior to the emplacement of two Texas Towers. According to Emery and Uchupi (1972) the towers were dismantled after heavy scour around the legs weakened them.

Thus the need for more detailed information before and during petroleum development is obvious. For example, water circulation must be documented with current meters and LaGrangian drifters, deployed year-around, and resulting data integrated with meterologic and density field observations. The character, composition, and distribution of suspended matter in the water column needs to be assessed. Mobility of bottom sediment and the extent of scour and deposition in various areas of the Bank need to be documented by direct observations and by geophysical methods because of their potential threat to structure stability. Similarly, the characteristics and physical properties of the upper 100 m of strata must be evaluated by analyzing samples from cores and by conducting high resolution seismic surveys first at a reconnaissance scale, and then in greater detail in lease areas and finally at specific drilling sites.

Purpose

The objectives of the geologic studies being carried out by the U.S. Geological Survey for the Bureau of Land Management are to assess the geologic hazards and to collect baseline data in the Georges Bank area prior to and during active drilling.

Specific questions being addressed include:

1. Does the Georges Bank gyre exist, and what are its major driving mechanisms?
2. What current patterns are established in response to wind stress?
3. What is the current flow through Great South and North channels?
4. What is the character, concentration, distribution, and flux of seston through the area?
5. What is the area and extent of surficial sediment mobility?
6. What are the physical properties of bottom and subbottom sediments? How do various strata react to loading?
7. Is the area underlain by faults? If so, do they offset the bottom?

The data generated will provide information needed to predict (1) oil spill trajectories (2) potential interactions of pollutants and suspended particulates, (3) potential stresses associated with wind, waves, currents, and scour that constitute the major threats to the stability of structures erected for development and transfer of oil, (4) the response of subbottom strata to loading and their suitability for setting casing under possible high pressure conditions.

Design of Program

USGS field work for first year geologic studies is complete with the exception of ongoing tripod deployments (Fig. 1).

Sediment Transport - One or two tripods will alternately be deployed. One, for example, was deployed on 30 October and recovered in December when two others were deployed.

Submersible Observations - Two cruises have been carried out during which 17 dives at 5 sites were conducted aboard Nekton Gamma and Nekton Beta. Railroad wheels, set on the bottom, were observed for evidence of long term scour, microtopography surveyed, sand wave movement documented, and biota observed.

Seston and Turbidity Measurements - Suspended matter and turbidity were assessed on 4 cruises, during which 307 samples were collected on the basis of transmissometer observations. Thirty liter capacity Niskin bottles and a transmissometer were mounted on a rosette sampler so that all data could be acquired simultaneously (Fig. 4).

Texture, Mineralogy, and Trace Metals - Twenty-one vibracores and 35 hydrostatically damped gravity cores were collected over the Bank and west of Great South Channel. Texture and trace metals have been measured in 100 samples taken from the cores(Fig. 5). C_{14} and mineralogic analyses have not yet been conducted.

Tectonic Hazards - Twenty-nine hundred km of minisparker data were collected aboard R/V Fay during the fall of 1975 to assess faulting and the geophysical characteristics of shallow strata underlying the Bank (Fig. 6).

Water Mass Transport - Current and pressure observations were carried out at 5 stations during 1975-76 for a one year period. Three other current meter moorings were deployed in and around Great South Channel in response to the need for hydrographic information following the ARGO MERCHANT oil spill.

Lab Procedures

Tripods - Data recovered from tripod instruments includes bottom photos, current direction and speed, light transmission, pressure, and temperature. About 1000 photos are taken during a 3 month deployment. They are processed in a flow camera system and the 8" x 10" positive prints are reviewed for ripple crest migration, number of organisms, turbidity, etc. Samples of current speed, pressure, temperature and light transmission are obtained every 7.5 minutes. Centered in this interval 16 samples of current speed, current direction, and pressure are taken over a 4-sec sample interval. These data are recorded on magnetic cassettes in the Sea Data Recording System. Cassette data are copied onto a 9 track tape with an HP computer and decoded with a Sigma 7 Computer into physical variables such as cm/sec, millibars, degrees Centigrade, and volts (for light transmission). For an initial look at data quality, interval and average quantities calculated from the burst are plotted. These data are scrubbed, truncated, and stored on 9 track tape, ready for analysis and correlation.

Seston - Rinsed frozen samples are air dried and weighed in the laboratory. Total seston concentration in the water are calculated. Filters are split and one half either treated with H_2O_2 or combusted at 500°C and the other half used for optical or scanning electron microscopy (100 x-8000x) study. Major elements in unidentified particles are analyzed with backscattering x-ray fluoresence. Transmissometer tapes are played back in the Montedoro-Whitney Beck Read-out to produce plots of light transmission and scattering, temperature, and conductivity versus depth.

Bottom Sediments - Vibracores and grab samples were described visually and subsampled for such parameters as texture, organic carbon, C_{14} and various elements. Texture was analyzed by sieving, rapid sediment analyzer, pipette and Coulter Counter. C_{14} analyses are to be carried out at the Radiocarbon Laboratory, USGS, Reston, VA.

Trace Metals - Analyses conducted on 100 samples were carried out by atomic absorption spectrophotometry at Analytical Laboratories, Reston, VA.

Geophysics - High resolution seismic records were flowed through a camera system and reduced. Copies were picked and plotted for presentation as cross-sections.

Water Mass Transport

AMF Vector averaging current meters (VACM) compute the vector average of current speed and direction over a 7.5 minute interval. Data are recorded on an internal cassette that stores vector averages of east and north and vector speed, plus temperature every 7.5 minutes. Draper Laboratories processes the raw tape and puts raw scale data on a nine track tape. Subsequent data handling is the same as that described for tripod instrument output.

Problems

Problems that have been encountered are mainly related to severe weather conditions, especially during winter, and to the abundant fishermen in the area. Submersible dives were limited due to fog, currents, and high seas and tripod turnarounds are inevitably slowed by heavy weather during winter. Several current meters have been returned by fishermen and one tripod was dragged several miles despite the presence of three large buoys moored around it. These incidents can be minimized by the use of well lighted buoys with large radar reflectors, but they still will occur because strong tides, dense fog, and high seas limit the effectiveness of all navigational aids and even the best seamanship.

Timing

See Figure 2.

Personnel

USGS principle investigators include B. Butman for sediment and water mass transport, M. Bothner for trace metals, sediments, and suspended matter, and R. Sylwester for tectonic hazards. Sub-contractors include J. Milliman and D. Hosom of the Woods Hole Oceanographic Institution, and A. Eliason of Eliason Associates.

Results

The tripod deployed on 30 October provided partial data for 35 days (Fig. 3). Turbidity varied with an increase in pressure fluctuation (waves) tidal currents, and with the movement of the temperature front that separates shelf from slope water.

Submersible observations revealed small 20 cm wavelength asymmetric ripples and larger (several meter wavelength) sand waves moving in response to tidally driven bottom currents. Scour was occurring in Great South Channel, but not on the south flank of the Bank in 85 m of water. No diving was carried out in water <70 m deep because current speeds were too high.

Transmissometer and suspended matter observations revealed a highly turbid layer (3.0 mg/l) on the south flank of the Bank that was composed mostly of organic material. Commonly, suspended matter concentrations in the entire water column varied between 0.1 and 2 mg/l.

Sediments on the Bank to a depth of 6 m are mainly sand (70-99%); but east of Great South Channel, clay and silt are more common (Fig.5).

Trace metals (Zn, Cu, Cr) show no systematic variation with depth. By partial leaching techniques zinc concentrations varied from <0.3 to 10.7 ppm, copper from <0.3 to 4.2 ppm, and chromium from <0.9 to 5.5 ppm.

High resolution seismic data reveal a 20-80 m thick Pleistocene (?) section of sediment overlying probable Tertiary and Cretaceous strata. This cover of coarse detritus contains acoustic evidence of several episodes of channel cutting and filling. Over the top of the Bank it forms sand waves several tens of meters high. The probable varied texture of the uppermost sediments may provide an unstable foundation for structures erected on it - and the mobility of its surface due to waves and currents clearly represents a hazard to the stability of buried structures such as pipelines.

Current meters deployed at 5 stations (Fig. 1) on and around the Bank reveal a clockwise mean flow that is particularly strong on the northern side. Complex circulation in Great South Channel is not well resolved but observations now being made at several sites by instruments deployed as the result of the ARGO MERCHANT oil spill will provide needed additional data. Strong tidal currents between 1-2 knots are common over the crest of the Bank.

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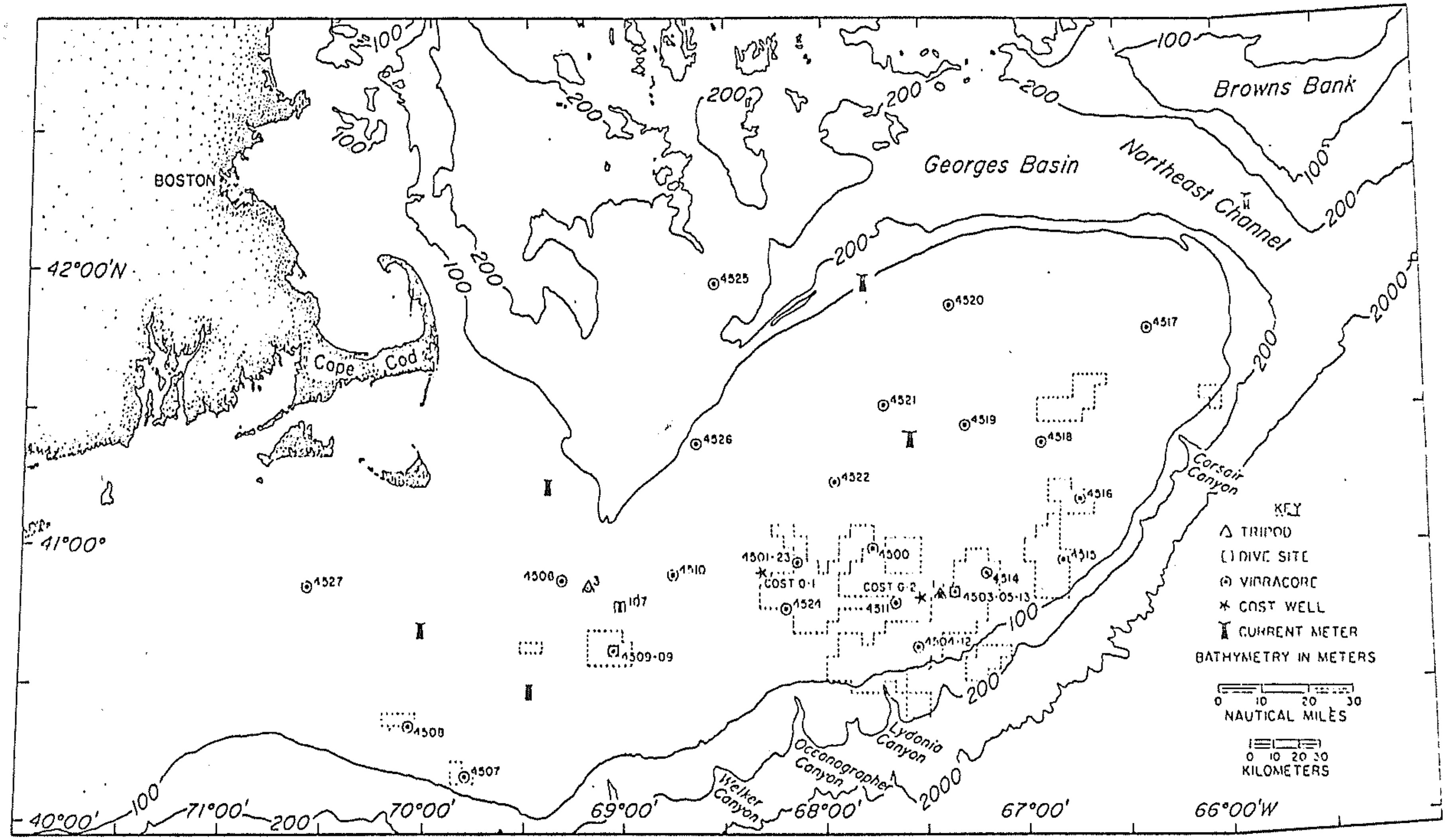
Browns Bank
Northeast Channel
Georges Basin
BOSTON
Cape Cod
Corsair Canyon
Lydonia Canyon
Oceanographer Canyon
Welker Canyon
42°00'N
41°00'
40°00'
71°00'
70°00'
69°00'
68°00'
67°00'
66°00'W
COST G-1
COST G-2
KEY
TRIPOD
DIVE SITE
VIBRACORE
COST WELL
CURRENT METER
BATHYMETRY IN METERS
NAUTICAL MILES
KILOMETERS

Figure 1

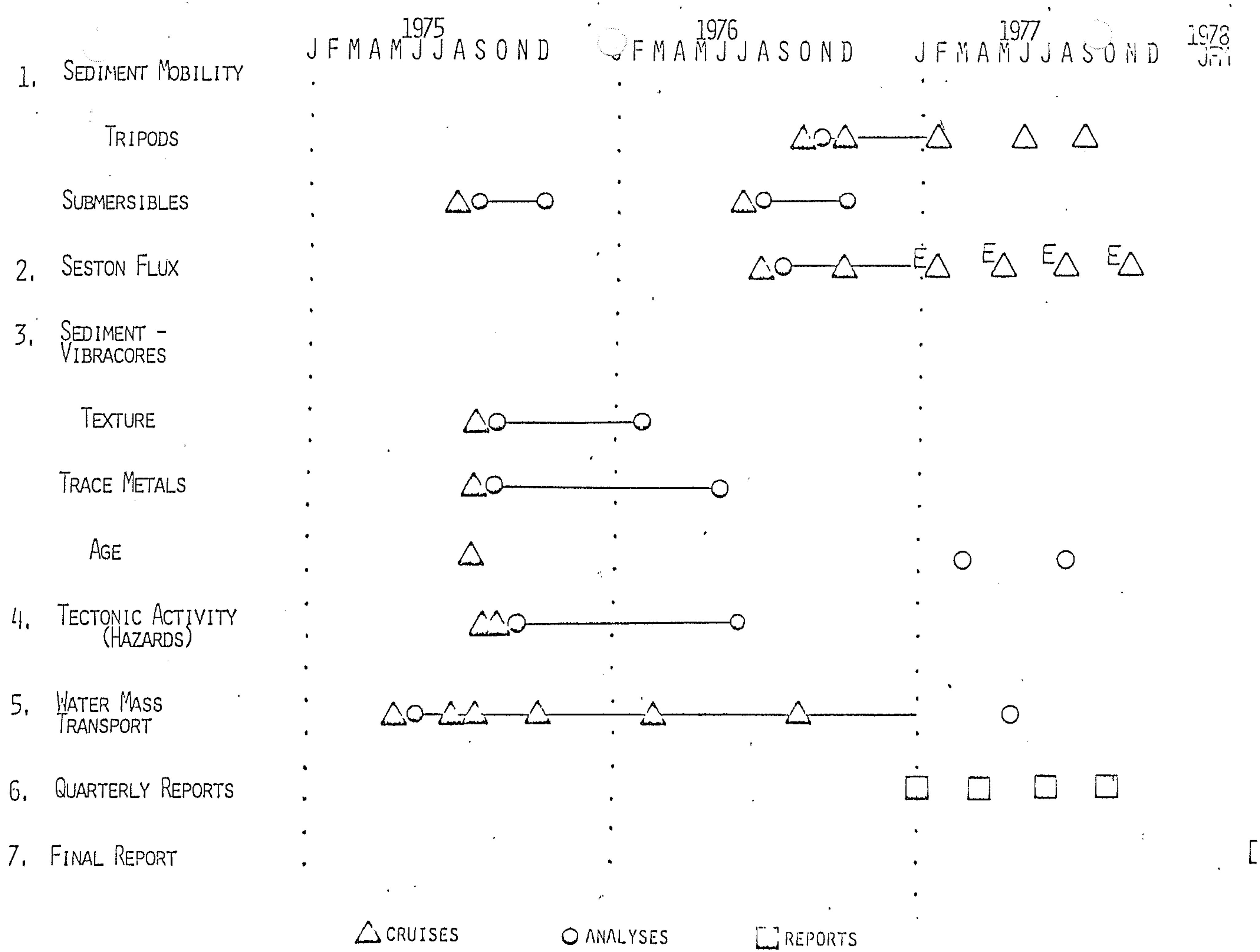
1975
J F M A M J J A S O N D
1976
J F M A M J J A S O N D
1977
J F M A M J J A S O N D
1978
1. SEDIMENT MOBILITY
TRIPODS
SUBMERSIBLES
2. SESTON FLUX
E
E
E
E
E
3. SEDIMENT - VIBRACORES
TEXTURE
TRACE METALS
AGE
4. TECTONIC ACTIVITY (HAZARDS)
5. WATER MASS TRANSPORT
6. QUARTERLY REPORTS
7. FINAL REPORT
CRUISES
ANALYSES
REPORTS

Figure 2

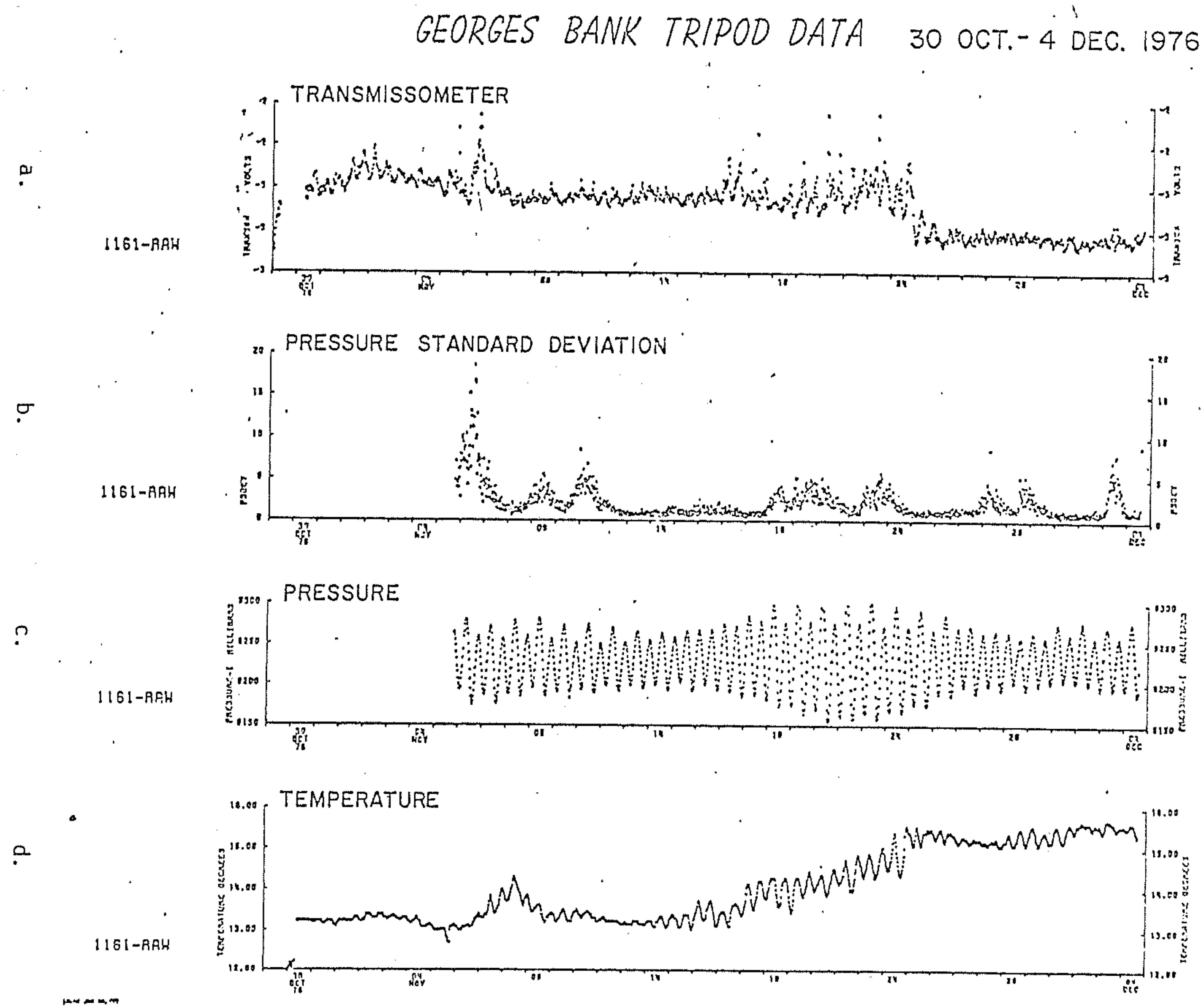
GEORGES BANK TRIPOD DATA 30 OCT.- 4 DEC. 1976
a.
1161-RAW
TRANSMISSOMETER
b.
1161-RAW
PRESSURE STANDARD DEVIATION
c.
1161-RAW
PRESSURE
d.
1161-RAW
TEMPERATURE

Figure 3

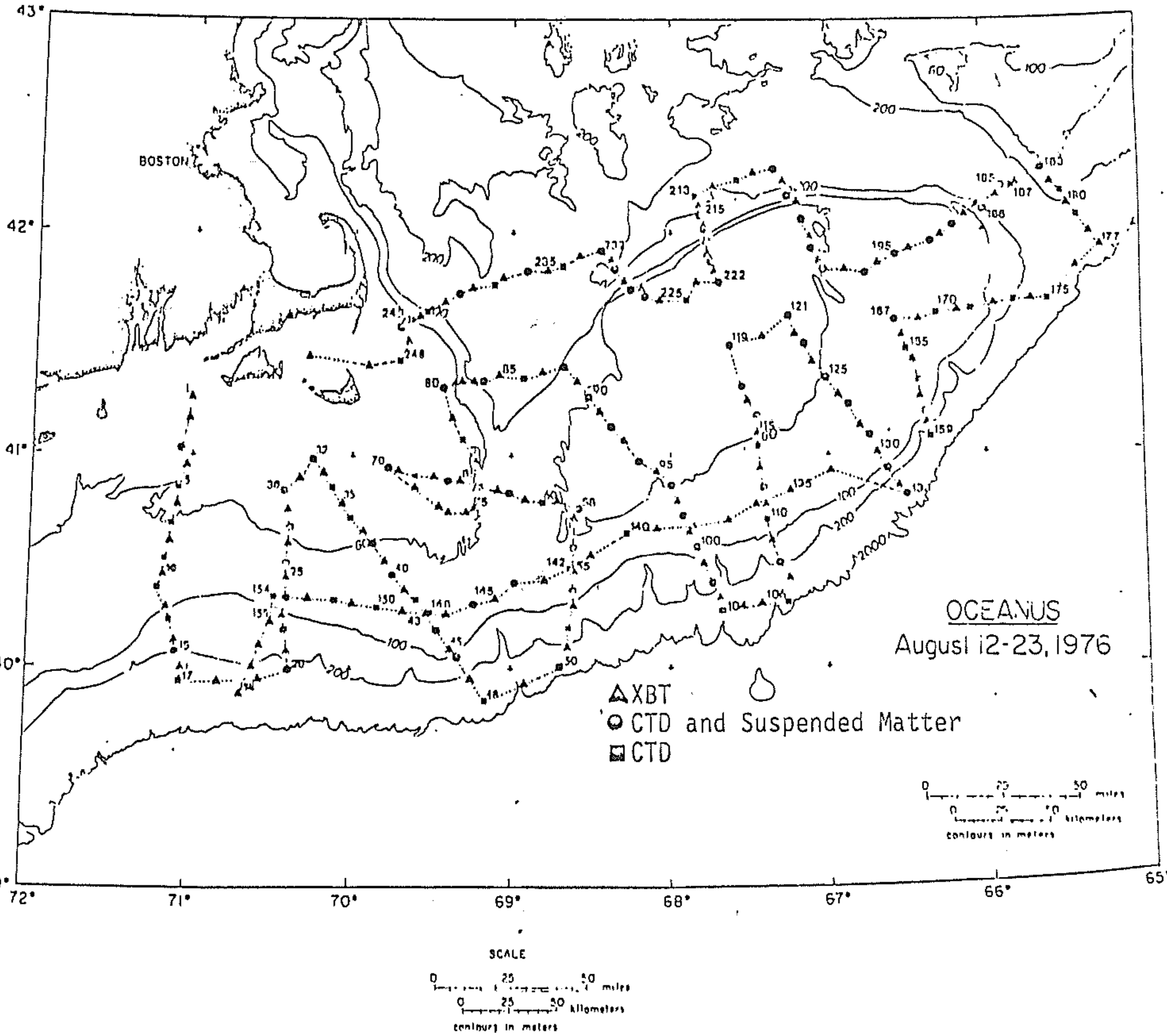
OCEANUS
August 12-23, 1976
XBT
CTD and Suspended Matter
CTD
BOSTON
SCALE
contours in meters

Figure 4

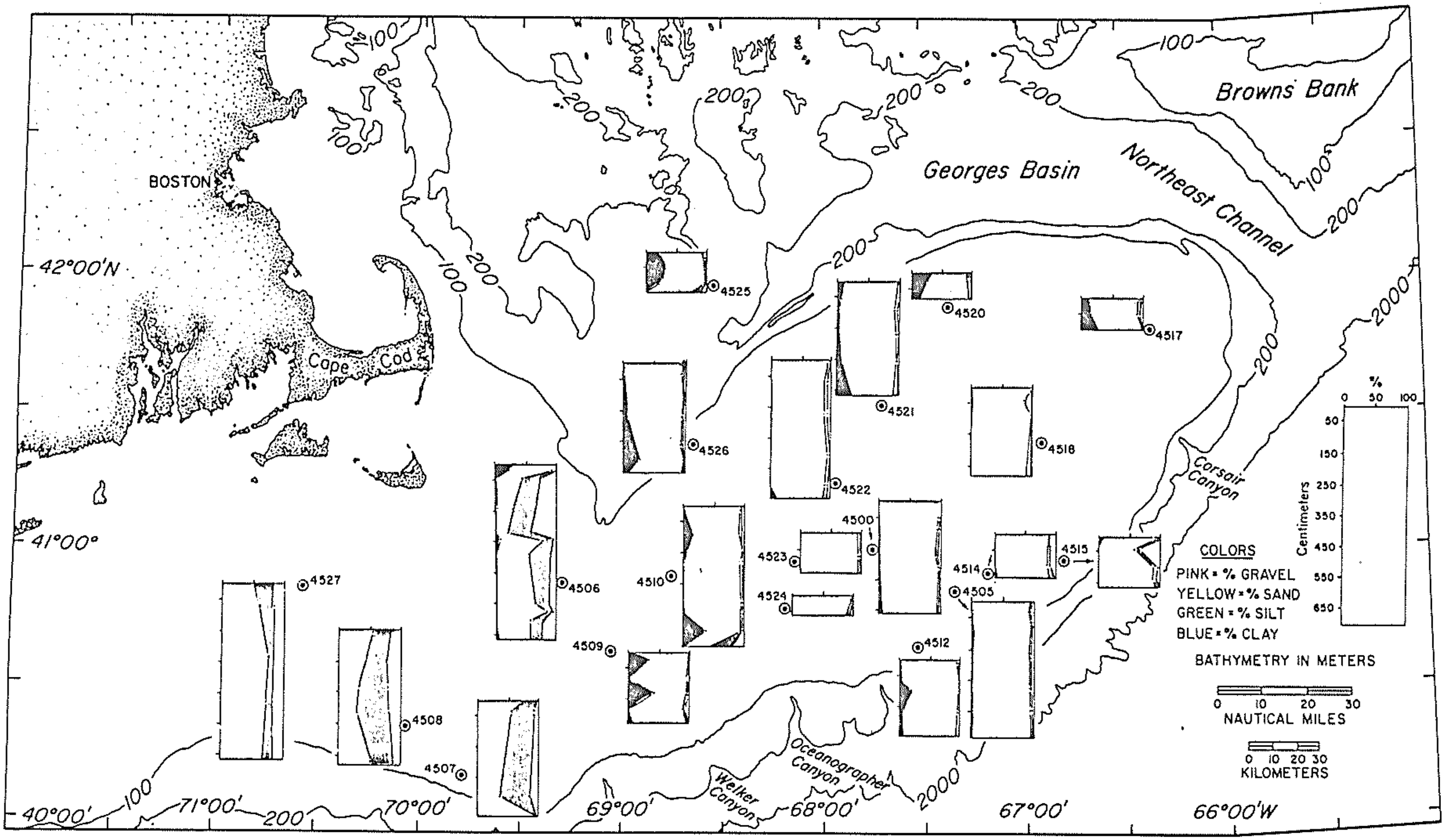
Browns Bank
Georges Basin
Northeast Channel
BOSTON
Cape Cod
42°00'N
41°00°
40°00'
71°00'
70°00'
69°00'
68°00'
67°00'
66°00'W
Corsair Canyon
Oceanographer Canyon
Welker Canyon
4500
4505
4506
4507
4508
4509
4510
4512
4514
4515
4517
4518
4520
4521
4522
4523
4524
4525
4526
4527
COLORS
PINK = % GRAVEL
YELLOW = % SAND
GREEN = % SILT
BLUE = % CLAY
BATHYMETRY IN METERS
NAUTICAL MILES
KILOMETERS
Centimeters
%

FIG 5

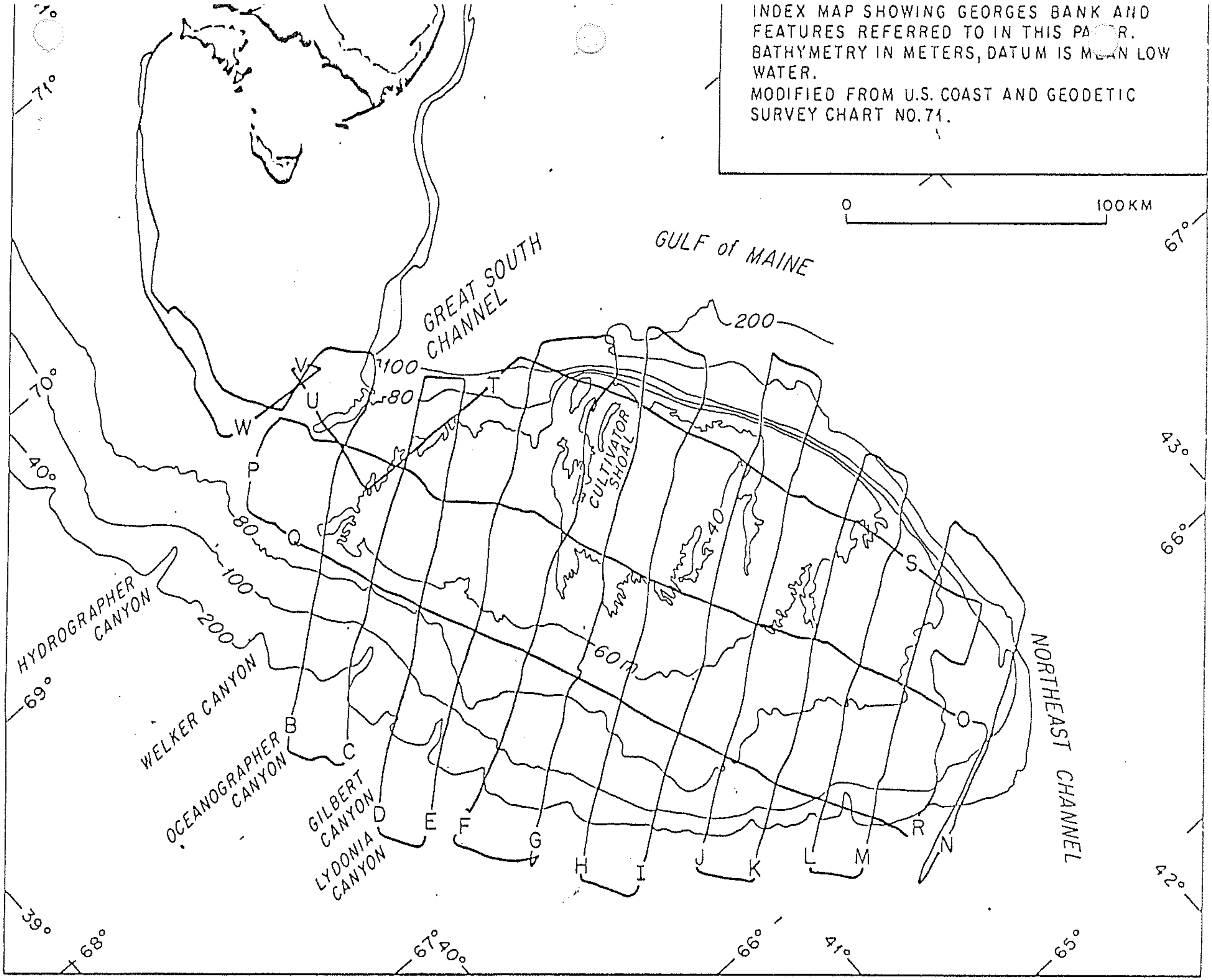
INDEX MAP SHOWING GEORGES BANK AND FEATURES REFERRED TO IN THIS PAPER. BATHYMETRY IN METERS, DATUM IS MEAN LOW WATER.
MODIFIED FROM U.S. COAST AND GEODETIC SURVEY CHART NO.71.
0
100KM
GULF of MAINE
GREAT SOUTH CHANNEL
CULTIVATOR SHOAL
NORTHEAST CHANNEL
HYDROGRAPHER CANYON
WELKER CANYON
OCEANOGRAPHER CANYON
GILBERT CANYON
LYDONIA CANYON
200
100
80
60m
40
71°
70°
69°
68°
67°
66°
65°
67°40°
43°
42°
41°
40°
39°
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W

Figure 6