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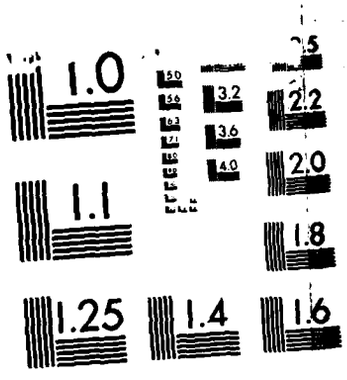

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APPLIED MARINE RESEARCH LABORATORY
OLD DOMINION UNIVERSITY
NORFOLK, VIRGINIA

MACROBENTHIC COMMUNITIES OF THE DAM NECK DISPOSAL SITE

By

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Final Report
For the period ended 31 July 1984

Prepared for the
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Macrobenthos are typical of those found in sandy, offshore areas of the mid-Atlantic. No commercially important benthic species found in DNDS. High degree of similarity to benthos of Norfolk Disposal Site.

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ABSTRACT

Non-commercial benthos were sampled quarterly at four Dam Neck Extension stations in 1983-84 and once at five Dam Neck Interim stations in July 1984. Five replicate Shipek Grabs were taken at each station and sediment grain-size analysis was performed on grab sub-samples. Commercial benthos were sampled seasonally on two occasions by three commercial dredge hauls at the Dam Neck Extension Site and by a single haul on one occasion at the Dam Neck Interim Site.

The dredges yielded low abundances of species of limited commercial value. Sediment analysis revealed two potential groups of stations. However, results of dominance analysis, principal component analysis and discriminant analysis indicate that benthic infauna at Dam Neck are assemblages within a single sandy-substrate community with some micro-habitat specific variation.

Comparision of benthic infaunal assemblages at the Norfolk Disposal Site by dominance analysis, principal component analysis and discriminant analysis indicate that they are components of the same community.

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INTRODUCTION

The distribution and abundance of benthic macroinvertebrates of the inner continental shelf south of the mouth of Chesapeake Bay were studied. Density dominants, number of organisms, number of species, species diversity indices and animal-sediment relationships were determined for data from nine stations. These stations were part of an environmental study of the area (designated as the Dam Neck Ocean Disposal Site Extension and Dam Neck Interim Ocean Disposal Site) proposed for open ocean disposal of dredged materials from the lower Chesapeake Bay (Alden et al. 1980, 1981a, 1981b). Four quarterly seasonal samples for non-commercial benthos were collected at each of the four Extension stations between November 1983 and July 1984, while the five Interim stations were visited in July 1984. Dam Neck Extension sites were sampled for commercially important benthos in early March and late May 1984, while the Interim Site was visited in July 1984.

The purpose of this study was (1) to present recent information concerning the structure of benthic macroinvertebrate communities of the Dam Neck Disposal Sites and (2) to compare data generated by this study with the results of longer-term studies on benthic macroinvertebrate communities of the Norfolk Disposal Site (Dauer, 1984a).

MATERIALS AND METHODS

Field Collection

The non-commercial macrobenthic invertebrate fauna of the inner continental shelf south of the mouth of the Chesapeake Bay was sampled. Four seasonal samples (November 1983 and February, April and July 1984) were collected at each of the Dam Neck Disposal Extension Site stations (A-D) and a single sample (July 1984) at the Interim Disposal Site stations (E-I). Each sample comprised five replicate Shipek grabs of surface area 0.04 m^2 each. The number of grabs (five) required to effectively and economically characterize the community was based on previous studies in the Chesapeake Bay and adjacent continental shelf (Dauer 1984a, 1984b) and determination that the communities and sediments collected did not differ obviously from the subjects of the prior studies.

The contents of each grab were gently washed through a 0.5 mm mesh-sized screen. Material retained in the screen was relaxed in dilute isopropyl alcohol, fixed and stained in a formalin-rose bengal solution. Fixed material was returned to the laboratory and organisms identified to lowest practical level and enumerated.

At each non-commercial benthos station a subsample comprising eight drams of sediment was retained for sediment

analysis. If the sediment from an individual grab changed markedly, an additional sediment subsample was taken. Sediment samples were dry sieved and mean particle size and sorting coefficients determined by the technique and equations of Folk (1974).

Commercially important benthos were sampled at the Dam Neck Extension Site using a commercial Clam Dredge in March 1984 and a commercial Rocking Chair Dredge in May 1984. On each day three ten-minute dredges were hauled as follows : (1) to the shoreward of the proposed bar (between non-commercial benthos stations A and C) (2) along the approximate center of the proposed bar and (3) to seaward of the proposed bar (between non-commercial benthos stations B and D). In May dredge two was hauled along the axis of the proposed bar, but to the south of its proposed position. Commercially important benthos at the Dam Neck Interim Disposal Site were sampled by one ten-minute Clam Dredge haul in July 1984.

Community Analysis

There is no universally acceptable approach to community analysis among workers in the field. Accordingly, a multifaceted range of techniques were adopted. All infauna collected were used in computation of commonly used indices of community structure. The Shannon-Weaver Diversity Index, Margalef's Species Richness Index, and Pielou's Eveness Index were calculated (see Ewing and Dauer, 1982 for further details).

Detailed multivariate statistical analysis of the communities was not attempted because results could be misleading due to limited temporal coverage, especially in the case of the Dam Neck Interim Disposal Site Stations. Instead, the stations were characterized by their sediments and scanned for differences in dominant organisms. The Biological Index Ranking (McCloskey 1970) was used.

A similar procedure was used to compare communities at the Dam Neck Stations with communities at the Norfolk Disposal Site (NDS). Dam Neck dominants were compared with NDS dominants over (1) all six years of NDS sampling, (2) combined 1983 and 1984 NDS sampling and (3) 1984 NDS samples only. This procedure was repeated after grouping stations by sediment characteristics. Inter-station relationships were also investigated using Principal Component Analysis based on the 20 most abundant species at the Dam Neck stations. The six years of data available from the Norfolk Disposal Site were included in this analysis.

Discriminant Analysis was performed on the above data using two approaches. In the first approach data from the four Extension stations were used to derive sediment group based classification functions. These classification functions were then used on data from (a) the Interim stations and (b) Norfolk Dumpsite stations and the accuracy of sediment group classification determined. In the second approach data from the Dam Neck and NDS studies were subjected to discriminant analysis and the ability

of the analysis to discriminate between biological samples by origin determined.

RESULTS

Site Characteristics

Sediment characteristics of the nine Dam Neck stations are presented in Table 1. All stations had high sand contents. The inshore Extension stations (A and C) were moderately sorted with a mean particle size in the fine to very fine sand range. Interim stations G, I and H had similar characteristics. The offshore Extension stations (B and D) were also moderately sorted, but less well than stations A and C. Mean particle size at these stations was in the coarse to medium sand range. Interim stations E and F had similar characteristics. There were two potential groups of stations based on sediment characteristics.

Hydrographic measurements at the stations are presented in Table 2. All values were within expected ranges.

Commercial Benthos

Results of dredges for commercially important benthos are presented in Table 3. Abundances were low and only species of marginal commercial importance were collected.

Community Analysis

Community parameters for Dam Neck stations are presented in Table 4. All results are within expected ranges and are comparable with values at the Norfolk Disposal Site (Dauer 1984a). In

general the offshore Extension stations with larger grain size (B and D) had greater numbers of organisms and number of species and higher diversity and richness than inshore stations A and C. This relationship did not hold for Interim stations, perhaps due to the patchy nature of the environment (sediment changes were encountered at two of the five stations).

The assemblage of organisms at Dam Neck stations represented a typical subtidal sandy substrate benthic community. Of the 134 taxa collected, Amastigos caperatus, Spiophanes bombyx, Mediomastus ambiseta, Cirratulidae and Polygordius spp. together with Oligochaetes and Nermerteans accounted for 70% of all organisms collected. A complete list of species collected is presented in the appendix.

The assemblages collected at all stations probably represent samples from a single community. Within the Extension community however, subtle differences in relative abundance exist between coarser sand offshore stations and finer sand inshore stations. Pseudunciola obliquua, Lumbrineris tenuis and Schistomeringos caeca were absent from inshore stations, but were 4th, 7th and 9th most abundant respectively, at offshore stations. Similarly Rhepoxynius (=Trichophoxus) epistomus was absent from offshore stations, but 5th most abundant at inshore stations A and C. These differences are attributable to differences in substrate grain size between micro-habitats. Pseudunciola obliquua is known to be more abundant in coarser sands while Lumbrineris

tenuis and *Schistomeringos caeca* are interstitial burrowers whose required habitat is absent in fine substrates. *Rhepoxynius epistomus*, on the other hand, is known to prefer fine and medium sand substrates.

Interim stations G, H and I, which had mean particle diameters similar to inshore Extension stations (although sorting coefficients varied) were similar in community structure to the inshore Extension stations. Community structure at Interim stations E and F was similarly allied to that at offshore Extension stations B and D.

Station I was intended as a control site for the Interim stations. However, sediments here were much lower in sand content, sorted more poorly, and had lower mean particle size than all other stations. However community structure was similar to that of other 'fine' stations. This similarity illustrates the rationale behind considering fauna in the Dam Neck area a single community showing micro-habitat related local variation.

This conclusion was supported, though not unequivocally, by discriminant analysis. The analysis was 100% accurate in classifying infauna from fine samples and 75% accurate in classifying infauna from coarse samples. It was only 30% correct in classifying Interim samples based on classification functions derived for the 'top 20' dominants at the Extension stations.

DISCUSSION

Community Characterization

The benthic macroinfaunal community in the Dam Neck Disposal Site area may be considered a typical sandy substrate assemblage. Species restricted to sandy substrates, or known to prefer them, such as *Spiophanes bombyx*, *Pseudunciola obliquua*, *Tellina agilis*, *Amastigos caperatus*, *Apoprionospio pygmaea*, *Pectinaria gouldi* and *Asabellides oculata* occurred with greater consistency and abundance than habitat generalists such as *Mediomastus ambiseta* and *Polydora ligni*. This may indicate an environment under low natural and anthropogenic stress.

The community shows local variation related closely to mean particle size of the habitat. Although a few species showed disjunct distributions, the large majority were simply more abundant in coaser sediments, thus showing a different relative abundance (see also Dauer 1984a). The stations visited probably represented samples from a community which was a continuum with micro-habitat related local variation.

In view of the temporally limited scope of sampling, especially for the Interim stations, no analysis of temporal trends was attempted. Further, the data were considered inadequate for all but exploratory statistics.

Comparision with the Norfolk Disposal Site

Three methods were used for comparision of biological species assemblages from the Norfolk Disposal Site with those from the Dam Neck stations. Comparision of dominants from 1979-1984, 1983-84 and 1984 sampling periods at the Norfolk Disposal Site (Table 5) showed essentially the same assemblage of species as the Dam Neck stations, although differences in relative abundance and some qualitative differences existed. All 'top 20' dominants at the Norfolk Disposal Site were found during Dam Neck sampling. There was 60-70% correspondence between 'top 5', 'top 10' and 'top 20' species lists. Overall, it would appear that the same general benthic macroinvertebrate community exists at the Dam Neck and Norfolk Disposal Sites with some micro-environment specific variation.

This thesis was further investigated using Principal Component Analysis. The first two principal components explained 98% of the variance associated with the 'top 20' Dam Neck dominants in the entire data set. This is unusual for species-abundance data and by itself supports the contention that all samples are from a single community. The position of samples from the different studies showed a high degree of overlap with some separation by sediment characteristics. Figure 2 shows the position of six year Norfolk Disposal Site site means (n=135) in relation to Dam Neck station cruise means (n=5).

Discriminant analysis (approach 2) was used to classify samples from the NDS and Dam Neck Sites based on the 'top 20' Dam

Neck dominants in the data set. Classification of the 1979-84 and 1983-84 NDS data against the Dam Neck station data yielded similar results. The NDS samples were classified with 86% accuracy for the former and 85% for the latter. Accuracy for Dam Neck sample classification was 63% and 65% respectively. Taking into account the high accuracy with which discriminant models usually classify communities (see Dauer 1984a pp 13, 30), these results indicate that the same general benthic macroinvertebrate community exists at the Dam Neck and Norfolk Disposal sites with some micro-habitat specific variation.

Monitoring Implications

Identification and quantification of temporal trends for the benthic macroinfaunal community is necessary in order to avoid drawing erroneous conclusions from data (Dauer 1984a). The temporal span of sampling from Dam Neck stations was limited, and especially so for Interim stations which were only visited once. A thorough understanding of the dynamics of the benthic macroinfaunal community requires sampling over extended periods. Seasonal trends can not be quantified unless sampling is replicated within biological and metereological seasons. The results of this study must therefore be regarded as a preliminary characterization of the benthic macroinfaunal community due to the limited scope of sampling.

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APPENDIX : SPECIES LIST FOR THE DAM NECK DISPOSAL SITES

CNIDARIA : ANTHOZOA

Anthozoa spp.

PLATYHELMINTHES TURBELLARIA

Turbellaria spp.

NEMERTEA

Nemertea spp.

ANNELIDA : POLYCHAETA

Amastigos caperatus Ewing and Dauer
Ampharete arctica Malmgren
Ampharetidae spp.
Ancistrosyllis hartmanae Pettibone
Apoprionospio pygmaea (Hartman)
Aricidea catherinae Laubier
Aricidea wassi Pettibone
Asabellides oculata (Webster)
Brania welfleetensis Pettibone
Capitella capitata (Fabricius)
Cirratulidae spp.
Cirrophorus furcatus (Hartman)
Clymenella torquata (Leidy)
Drilonereis magna Webster aNd Bdnedict
Drilonereis spp.
Eteone heteropoda Hartman
Eteone lactea Claparede
Flabelligera sp.
Glycera americana Leidy
Glycera dibranchiata Ehlers
Glycera spp.
Glycinde solitaria (Webster)
Goniadella gracilis (Verrill)
Hemipodus roseus Quatrefages
Leitoscoloplos fragilis (Verrill)
Lumbrineris fragilis (Muller)
Lumbrineris tenuis Verrill
Macroclymene zonalis (Verrill)
Magelona sp.
Maldanidae spp.
Mediomastus ambiseta (Hartman)
Microphthalmus sczelkowii Mecsnikow
Microphthalmus similis Bobretsky
Microphthalmus sp.
Nephtyidae spp.
Nephtys bucera Ehlers

ANNELIDA : POLYCHAETA (Contd)

Nephtys picta Ehlers
Notocirrus spiniferus (Moore)
Notomastus hemipodus Hartman
Notomastus latericeus Sars
Ophelia denticulata Verrill
Owenia fusiformis delli Chiaje
Paranaitis speciosa (Webster)
Paraonis pygoenigmatica Jones
Pectinaria gouldii (Verrill)
Pherusa sp.
Pista cristata (Muller)
Polycirrus eximius (Leidy)
Polydora ligni Webster
Polygordius spp.
Polynoidae sp.
Proceraea sp.
Protodorvillea kefersteini (McIntosh)
Sabellaria vulgaris Verrill
Schistomeringos caeca (Webster and Benedict)
Schistomeringos rudolphi (delle Chiaje)
Scoloplos rubra (Webster)
Sigambra tentaculata (Treadwell)
Sphaerosyllis hystrix Claparede
Spio setosa Verrill
Spiochaetopterus oculatus Webster
Spionidae spp.
Spiophanes bombyx (Claparede)
Sthenelais limicola (Ehlers)
Streblospio benedicti Webster
Streptosyllis pettiboneae Perkins
Syllides convoluta Webster and Benedict

ANNELIDA : OLIGOCHAETA
Oligochaeta spp.

MOLLUSCA : GASTROPODA
Acteocina canaliculata (Say)
Corambella depressa Balch
Cylichnella bidentata (Orbigny)
Epitonium angulatum (Say)
Gastropoda spp.
Mangelia cerina Kurtz and Stimpson
Nassarius trivittatus (Say)
Natica pusilla Say
Polinices duplicatus (Say)
Rictaxis punctostriatus (Adams)
Turbonilla interrupta (Totten)
Turbonilla spp.

MOLLUSCA : BIVALVIA
Bivalvia spp.
Ensis directus Conrad
Lyonsia hyalina Conrad

MOLLUSCA : BIVALVIA (Contd)

Mulinia lateralis (Say)
Mysella planulata (Stimpson)
Nucula proxima Say
Pandora bushiana Dall
Siliqua costata Say
Spisula solidissima (Dillwyn)
Tellina agilis Stimpson

ARTHROPODA : ISOPODA

Ancinus depressus (Say)
Chirodotea spp.
Cyathura polita (Stimpson)
Edotea triloba (Say)
Ptilanthura tenuis (Harger)

ARTHROPODA : AMPHIPODA

Acanthohaustorius millsi Bousfield
Ampelisca vadorum Mills
Ampelisca verrilli Mills
Batea catharinensis Muller
Byblis serrata Smith
Caprellidae spp.
Corophium spp.
Gammarus sp.
Listriella barnardi Wigley
Protohaustorius spp.
Pseudunciola obliquua (Shoemaker)
Rhepoxynius epistomus (Shoemaker)
Synchelidium americanum Bousfield
Trichophoxus floridanus (Shoemaker)
Unciola irrorata Say
Unciola serrata Shoemaker
Unciola spp.

ARTHROPODA : CUMACEA

Cyclaspis varians Calman
Oxyurostylis smithi Calman

ARTHROPODA : MYSIDACEA

Mysidopsis bigelowi Tattersall
Neomysis americana (Smith)

ARTHROPODA : TANAIDACEA

Leptognatha caeca (Harger)

ARTHROPODA : DECAPODA

Cancer irroratus Say
Pagurus spp.
Pinnixa chaetopterana Stimpson
Pinnotheridae spp.

PHORONIDA

Phoronis psammophila Cori

ECHINODERMATA : ASTEROIDEA
Asterias forbesii (Desor)

ECHINODERMATA : ECHINOIDEA
Arbacia punctuata (Lamarck)
Echinarachnius parma (Larmack)
Mellita quinquiesperforata (Leske)

ECHINODERMATA : HOLOTHUROIDEA
Leptosynapta inhaerens (Ayres)

ECHINODERMATA : OPHIUROIDEA
Ophiuroidea spp.

CHORDATA : HEMICHORDATA
Saccoglossus spp.

CHORDATA : UROCHORDATA
Cnemidocarpa mollis (Stimpson)

CHORDATA : CEPHALOCHORDATA
Branchiostoma virginiae Hubbs

TABLE 1 : Sediment Characteristics of Dam Neck Stations

(A) - Dam Neck Extension Stations : Means and standard errors are given for each parameter.

Station	Mean Phi	Sorting Coefficient	% Sand
A	3.23 (0.03)	0.62 (0.02)	94.5 (1.56)
B	0.83 (0.04)	0.84 (0.03)	99.7 (0.04)
C	3.22 (0.22)	0.60 (0.001)	96.7 (0.22)
D	1.65 (0.24)	0.89 (0.09)	92.7 (3.81)

(B) - Dam Neck Interim Stations : Means and standard errors are given where sediment changes occurred.

Station	Mean Phi	Sorting Coefficient	% Sand
E	1.22	0.95	99.9
F	2.10 (0.15)	0.83 (0.07)	99.5 (0.03)
G	3.21	0.63	95.0
H	2.61 (0.33)	0.72 (0.07)	96.9 (1.12)
I	3.94	1.07	56.47

TABLE 2 : Hydrographic Measurements at Dam Neck Stations

(A) - Dam Neck Extension Stations

Station	Date	Bottom Salinity (ppt)	Bottom Temperature (°C)	Depth (m)
A	11.01.83	28.91	16.04	9.0
	02.02.84	28.01	3.37	10.0
	04.19.84	24.13	9.30	9.0
	07.02.84	28.96	15.90	9.3
B	11.01.83	29.55	16.22	16.8
	02.02.84	30.40	3.63	17.8
	04.19.84	28.26	7.72	17.1
	07.02.84	30.74	13.90	17.0
C	11.01.83	28.94	16.47	9.3
	02.02.84	28.61	3.39	10.0
	04.19.84	25.22	8.90	9.7
	07.02.84	29.00	17.28	9.8
D	11.01.83	28.58	15.98	15.7
	02.02.84	20.42	1.84	16.3
	04.19.84	22.60	9.35	16.3
	07.02.84	36.40	13.34	16.7

(B) - Dam Neck Interim Stations

E	07.02.84	30.20	14.06	12.3
F	07.02.84	29.10	14.80	12.7
G	07.02.84	27.86	20.64	13.3
H	07.02.84	30.50	13.74	13.7
I	07.02.84	30.90	12.35	14.3

TABLE 3 : Results of Commercial Benthos Sampling : Total numbers of individuals in ten minute dredges.

	Extension March 1984			Extension May 1984			Interim July 1984
	1	2	3	1	2	3	1
Asterias forbesii	0	100+	10	0	0	0	0
Busycon canaliculata	0	0	0	1	1	0	0
Busycon carica	0	0	0	0	0	3	2
Cancer irroratus	10	16	1	0	0	0	1
Crangon septemspinosa	0	10+	0	0	0	0	0
Limulus polyphemus	2	1	0	0	0	0	0
Pagurus spp.	0	2	20	0	0	0	0
Polinices duplicatus	0	0	0	0	0	0	8

TABLE 4 : Community Parameters at Dam Neck Stations. H'- Shannon-Weaver Diversity, J'- Pielou's Evenness, SR- Margalef's Species Richness.

(A) - Dam Neck Extension Stations

Site	Date	Ind./m^2	# Species	H'	J'	SR
A	11.01.83	449	19	3.41	0.80	3.98
	02.02.84	395	14	2.65	0.70	2.96
	04.19.84	703	27	3.50	0.74	5.23
	07.02.84	1537	30	2.74	0.56	5.04
B	11.01.83	2484	28	2.73	0.57	4.33
	02.02.84	6978	24	2.34	0.51	3.17
	04.19.84	2743	25	2.26	0.49	3.79
	07.02.84	2718	41	4.15	0.78	6.33
C	11.01.83	898	26	3.28	0.70	4.79
	02.02.84	234	16	3.11	0.78	3.87
	04.19.84	800	23	3.06	0.68	4.31
	07.02.84	1137	24	2.30	0.50	4.22
D	11.01.83	1874	34	3.51	0.69	5.55
	02.02.84	2655	31	2.85	0.58	4.76
	04.19.84	800	27	4.02	0.85	5.10
	07.02.84	2420	42	3.93	0.73	6.61

(B) - Dam Neck Interim Stations

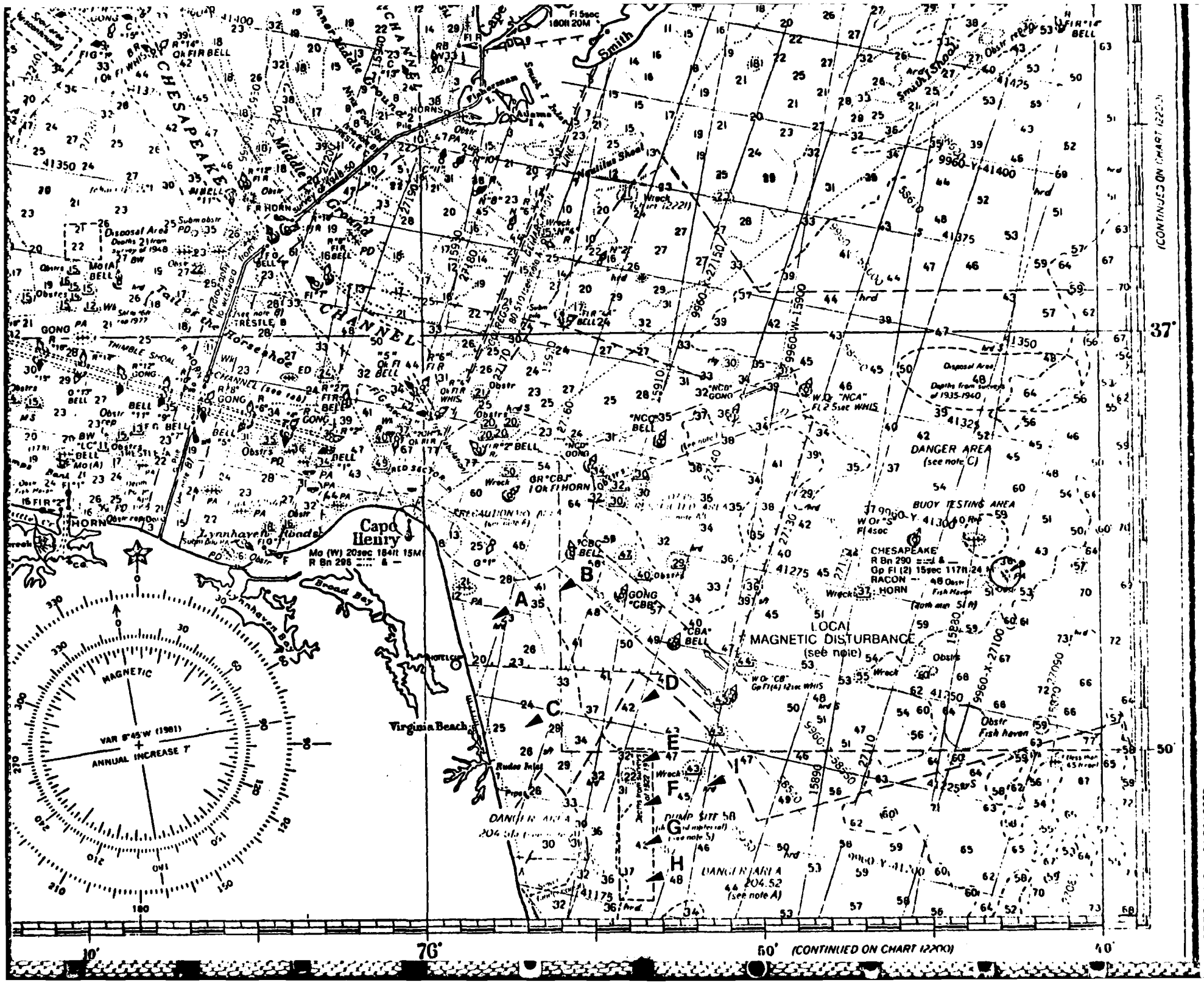
E	07.02.84	1591	40	3.66	0.69	6.74
F	07.02.84	1279	30	3.32	0.68	5.21
G	07.02.84	2664	29	2.62	0.54	4.44
H	07.02.84	2157	37	3.63	0.70	5.91
I	07.02.84	3148	46	3.65	0.66	6.96

TABLE 5 : Comparision of Abundance Order of Dam Neck 'Top 20' dominants with Norfolk Disposal Site Abundance Order. A - Dam Neck Order, B - NDS 1979-84 Order, C - NDS 1983-84 Order, D - NDS 1984 Order.

Species	A	B	C	D
Amastigos caperatus	1	8	4	3
Polygordius spp.	2	1	1	1
Spiophanes bombyx	3	3	5	10
Mediomastus ambiseta	4	13	11	9
Pseudunciola obliquua	5	60	51	122
Apoprionospio pygmaea	6	5	3	6
Tellina agilis	7	7	7	15
Pectinaria gouldi	8	99	99	74
Aricidea catherinae	9	11	9	8
Spio setosa	10	2	23	16
Asabellides oculata	11	33	20	23
Lumbrineris tenuis	12	22	36	29
Schistomeringos caeca	13	32	27	21
Ensis directus	14	19	8	4
Asterias forbesii	15	34	29	34
Glycera dibranchiata	16	45	38	32
Nephtys picta	17	9	10	14
Trichophoxus floridanus	18	27	22	19
Rhepoxynius epistomus	19	81	76	91
Polydora ligni	20	114	66	40

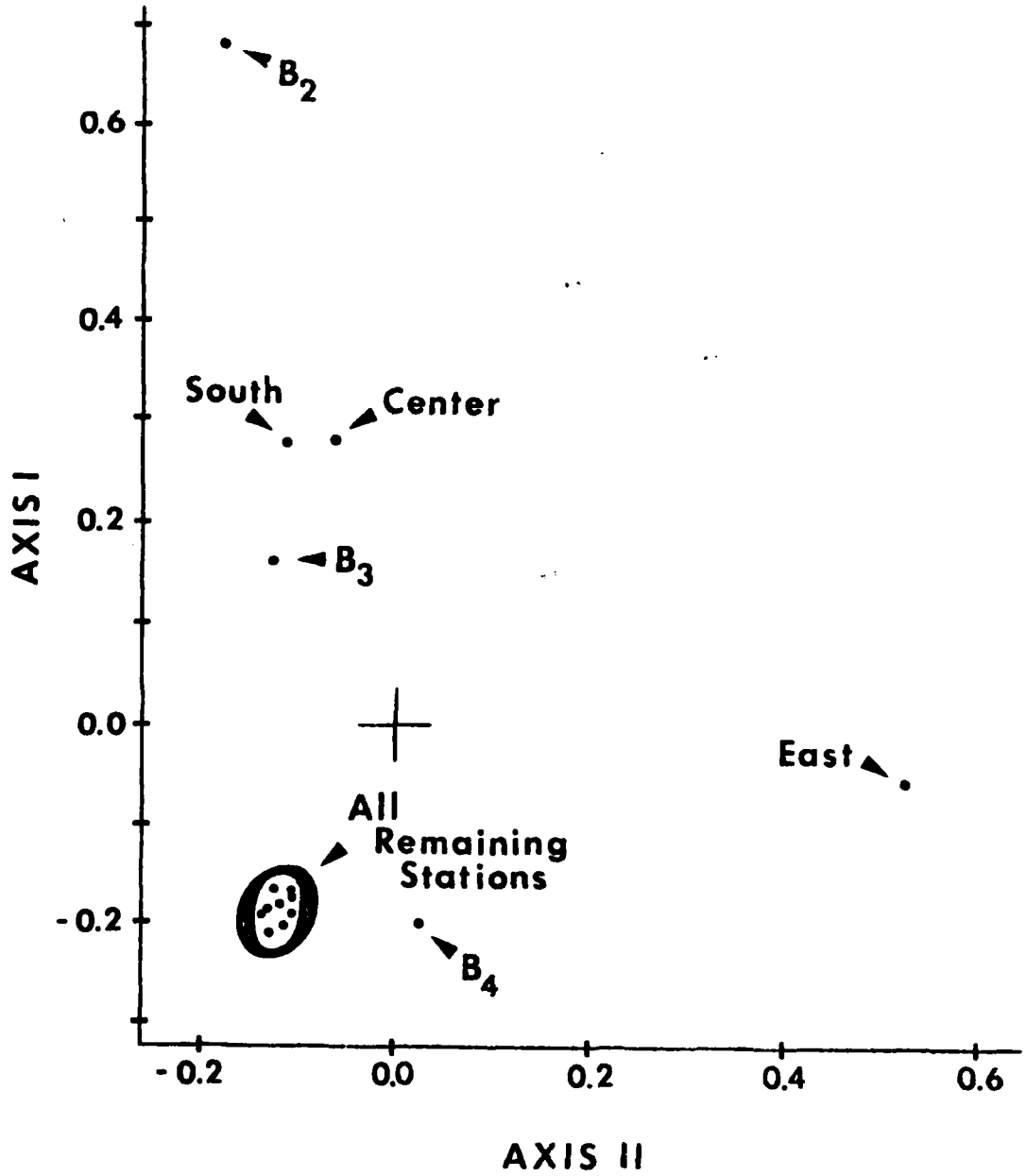
Note: Taxonomically problematic taxa that cannot be accurately identified to species level (Oligochaeta, Nemertea and Cirratulidae) were excluded from this analysis.

FIGURE1 : Study Area showing Sampling Stations. A - D : Dam Neck Extension stations; E - I : Dam Neck Interim stations.



CHESAPEAKE
CHANNEL
Middle Ground
Tail of the Horseshoe
Smith
Smith I Shoal
Nautilus Shoal
Cape Henry
Lynnhaven Roads
Lynnhaven Bay
Broad Bay
Virginia Beach
Rudee Inlet
DANGER AREA
(see note C)
BUOY TESTING AREA
CHESAPEAKE
RACON
HORN
LOCAL
MAGNETIC DISTURBANCE
(see note)
DUMP SITE 58
DANGER AREA
204.52
(see note A)
Disposal Area
Depths from surveys of 1935-1940
Obstr
Fish haven
MAGNETIC
VAR 8°45'W (1981)
ANNUAL INCREASE 7'
37°
50'
76°
10'
40'
(CONTINUED ON CHART 12200)

FIGURE 2 : Position of Norfolk and Dam Neck Disposal Site station means on first two principal axes of 'top 20' infaunal dominant data. East, Center and South refer to Norfolk Disposal Site stations; B - see Fig. 1, subscripts refer to Cruise Number.


B2
0.6
0.4
South
Center
AXIS I
0.2
B3
0.0
East
All
Remaining
Stations
-0.2
B4
-0.2
0.0
0.2
0.4
0.6
AXIS II

DTIC
FILMED
4-86
END