Monitoring Cruise at the New London Disposal Site, June - July 1990

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The objectives of the 1990 monitoring cruise at the New London Disposal Site were 1) to delineate the extent and topography of dredged material deposited since the August 1988 survey, 2) to determine mound stability, and 3) to assess near-bottom dissolved oxygen concentrations relative to REMOTS benthic analyses. Sampling was concentrated at two regions of recent disposal activity. The first location, designated NL-TR, was a region where sediments unsuitable for unconfined open water disposal were covered with a cap of clean material during early 1989. The second disposal location, identified as NL-88, was immediately adjacent (150 m west) to the former active mound listed as NL-85 in the July-August 1988 survey.

The bathymetric survey revealed that 46,700 m^3 of new sediment had accumulated in the vicinity of the NL-TR capped mound since the July-August 1988 survey. The radius of dredged sediment deposited at NL-TR was approximately 550 x 400 m, and benthic recolonization was largely as anticipated, indicating a healthy recovery well within expected recolonization rates. A comparison of precapping and postcap bathymetry indicated less than 50 cm of cap material on three of the six disposal points designated for the 1988 capping operation. However, it is believed that consolidation of the underlying dredged material may have contributed to the apparent diminished cap thickness. As a precaution, future disposal operations should be directed to these three capping points.

The bathymetric survey also indicated an accumulation of an additional 11,560 m^3 of material in the southern portion of the disposal site at disposal mounds NL-85 and NL-88. The REMOTS survey at NL-85 found that dredged material was distributed across the mound and that benthic recolonization was substantially as predicted (Stage II & III)

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EXECUTIVE SUMMARY

Material dredged from the Thames Shipyard and Repair Company was released in the northeast quadrant of the New London Disposal Site in October 1988, forming the NL-TR disposal mound. The 13,303 m^3 of dredged material was classified as unsuitable for unconfined open water disposal and was capped with 59,500 m^3 of clean material between 23 October 1988 and 23 January 1989. After a survey of the capped site in February 1989 it was recommended that additional cap material be released at the site. From 13 March to 17 June 1990, 39,483 m^3 of supplemental material was deposited.

In addition to the 1989 and 1990 capping operations, approximately 21,200 m^3 of dredged material from Noank and Mystic, CT was released at Buoy 88 (41°16.100′ N, 72°04.350′ W), a separate disposal point approximately 700 m south of the NL-TR disposal mound. The objectives of the most recent monitoring cruise at the New London Disposal Site were 1) to delineate the extent and topography of dredged material deposited since the August 1988 survey, 2) to determine mound stability, and 3) to assess near-bottom dissolved oxygen concentrations relative to REMOTS® benthic analyses.

Sampling was concentrated at two regions of recent disposal activity. The first location, designated NL-TR, was a region where sediments unsuitable for unconfined open water disposal were covered with a cap of clean material during early 1989. The second disposal location, identified as NL-88, was immediately adjacent (150 m west) to the former active mound listed as NL-85 in the July–August 1988 survey (SAIC 1990d).

The bathymetric survey revealed that 46,700 m^3 of new sediment had accumulated in the vicinity of the NL-TR capped mound since the July–August 1988 survey. The radius of dredged sediment deposited at NL-TR was approximately 550 m × 400 m, and benthic recolonization was largely as anticipated, indicating a healthy recovery well within expected recolonization rates. A comparison of precapping and postcap bathymetry indicated less than 50 cm of cap material on three of the six disposal points designated for the 1988 capping operation. However, it is believed that consolidation of the underlying dredged material may have contributed to the apparent diminished cap thickness. As a precaution, future disposal operations should be directed to these three capping points.

The bathymetric survey also indicated an accumulation of an additional 11,560 m^3 of material in the southern portion of the disposal site at disposal mounds NL-85 and NL-88. The REMOTS® survey at NL-85 found that dredged material was distributed across the mound and that benthic recolonization was substantially as predicted (Stage II and III).

Water column profiles of temperature, salinity, and density (sigma-t) showed that little stratification of the water column existed during the period of the survey. Near-bottom dissolved oxygen concentrations were uniformly high at all stations, both on and off the disposal site, and there was no indication that dredged material disposal operations were adversely influencing oxygen concentrations in the region.

1.0 INTRODUCTION

The New London Disposal Site covers a one square nautical mile area and is centered at latitude 41°16.100′ N and longitude 72°04.600′ W. It is located approximately three nautical miles south of Eastern Point, Groton, CT (Figure 1-1). This site has been monitored by the Disposal Area Monitoring System (DAMOS) Program since 1977. Several disposal mounds currently exist at New London as a result of past and recent disposal operations.

Field operations were conducted from 28 June to 9 July 1990. Sampling tasks included precision bathymetric and REMOTS® sediment-profile photographic surveys around the points where the disposal buoy was located during the 1989–90 disposal season (Figure 1-2). Previous surveys of the entire disposal site occurred in July 1986, July 1987, and July and August 1988. To understand the specific questions addressed in the present survey, it is helpful to examine the chronology of disposal operations at the New London Disposal Site during the past two years.

Following the 1988 master survey, a temporary buoy was placed in the northeast quadrant of the site at 41°16.425′ N, 72°04.320′ W for deposition of sediment generated by dredging activities at the Thames Shipyard and Repair Company Project (Table 1-1). These sediments were classified as unsuitable for unconfined open water disposal. The mound formed as a result of this project is referred to as NL-TR (Figure 1-2). On 17 October 1988, an 800 × 800 m postdisposal survey encompassing the NL-TR region was conducted to determine the distribution of dredged material (SAIC 1988). Subsequently, capping material was deposited at six locations (Table 1-2) surrounding NL-TR to cover the dredged material from the Thames Shipyard and Repair Company (SAIC 1988). Capping operations took place from 23 October 1988 to 23 January 1989, and resulted in the deposition of an estimated 59,500 m^3 of dredged material, based on barge logs. The report from the postcapping bathymetric survey of February 1989 recommended that additional material be deposited at locations "A", "B", "C", and "F" (Table 1-1) due to inadequate cap thickness (SAIC 1990a). Disposal at NL-TR resumed on 13 March 1990, and continued through 17 June 1990 (Buoy 90; Table 1-1, Figure 1-2). Barge logs indicate that 39,483 m^3 of dredged material was released during that time.

Since the 1988 master survey, dredged material has also been disposed at Buoy 88 (41°16.100′ N, 72°04.350′ W) approximately 700 m south of the NL-TR region and 150 m west of the NL-85 mound (Table 1-1, Figure 1-2). From 25 January to 10 March 1989, and from 30 October 1989 to 16 February 1990, approximately 21,200 m^3 of dredged material was deposited at this location.

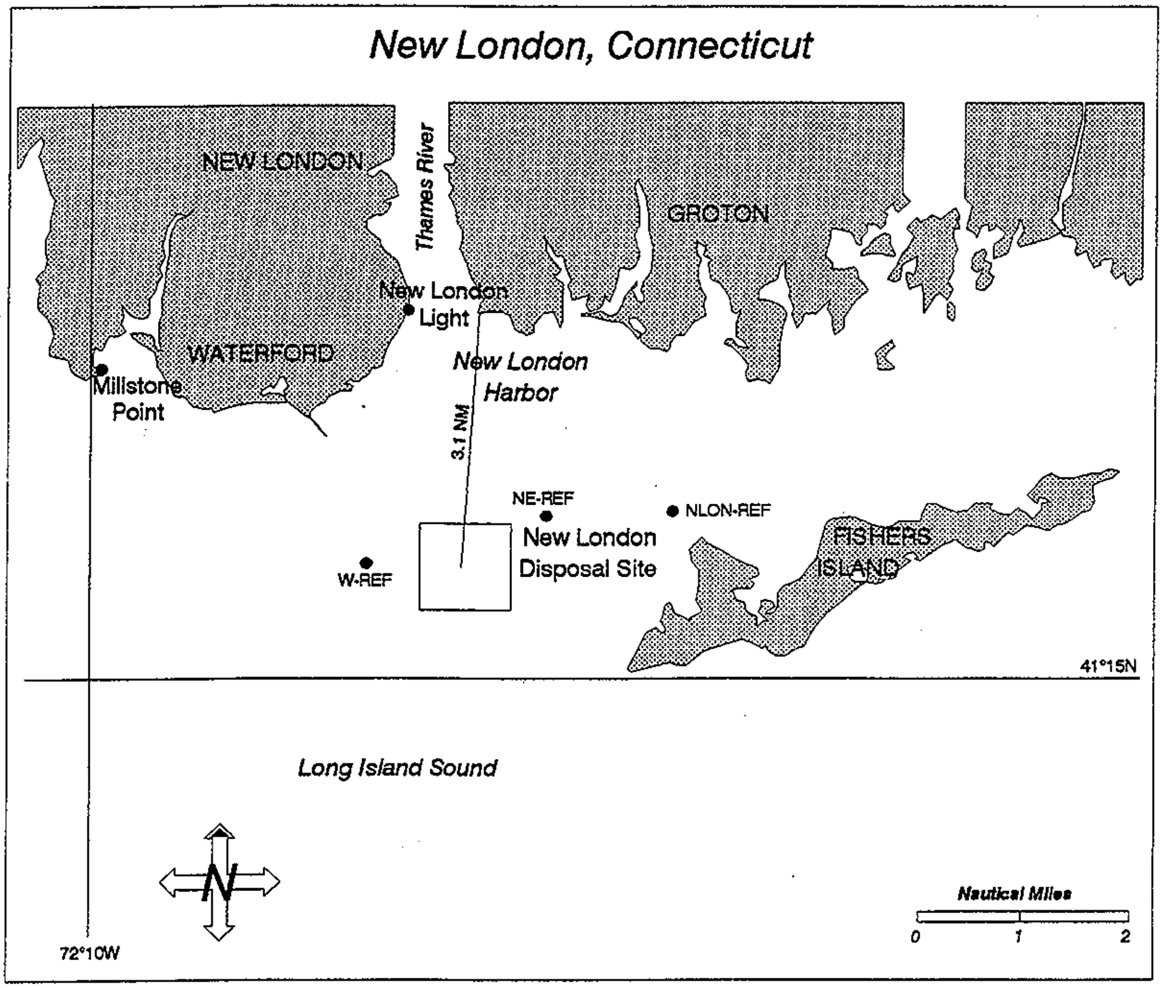


Figure 1-1. Location of the New London Disposal Site and reference stations in relation to Eastern Point, Groton, CT

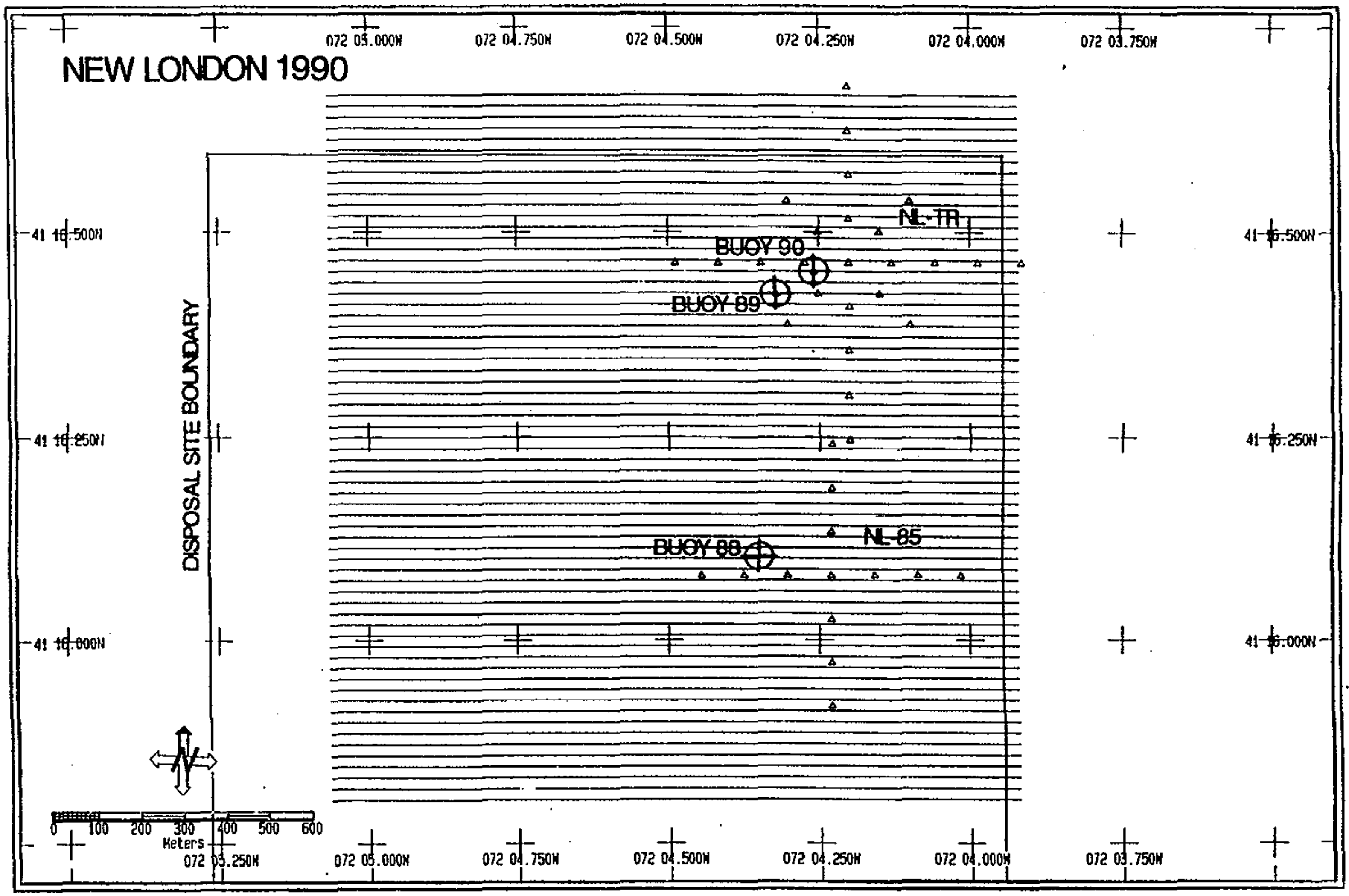


Figure 1-2. Map of New London Disposal Site precision bathymetric survey lanes and REMOTS® survey grid occupied in 1990

Table 1-1

New London Buoy History

Buoy	Location	Associated Mound
BUOY 88	41°16.100′ N 72°04.350′ W	NL-88
BUOY 89	41°16.430′ N 72°04.320′ W	NL-TR
BUOY 90	41°16.450′ N 72°04.260′ W	NL-TR

Table 1-2

Recommended Disposal Site Stations for Capping Material at NL-TR
(from SAIC 1988)

			(-) LORAN-C	
Station	**Latitude**	**Longitude**	**X-ray**	**Yankee**
A	41°16.423′	72°04.270′	26133.0	43976.5
B	41°16.416′	72°04.176′	26132.2	43976.3
C	41°16.359′	72°04.373′	26133.8	43976.2
D	41°16.378′	72°04.235′	26132.6	43976.1
E	41°16.385′	72°04.137′	26131.7	43976.0
F	41°16.416′	72°04.325′	26133.5	43976.5

Given the above disposal history, the objectives of the present survey were to

1) assess the extent, topography, and effective coverage of cap material added to the NL-TR region since the October 1988 postdisposal survey;
2) determine the status of benthic recolonization and mound stability at the inactive NL-85 disposal mound;
3) measure the extent and topography of dredged sediment deposits at the NL-88 mound; and
4) assess near-bottom dissolved oxygen concentrations relative to REMOTS® benthic analyses at and near the disposal site.

The 1990 monitoring scheme at the New London Disposal Site was designed to test the following predictions:

- Sediment disposed at the NL-85 mound would have a minimal effect on mound height; possibly there would even be a decrease due to consolidation. Benthic recolonization in this area would be primarily at Stage II and III.

- Disposal at the present buoy position (Buoy 90) would have deposited new material within a radius of 250-300 meters. Benthic recolonization in the central portion of this region would be at Stage I, whereas the margins of the mound would exhibit Stage II, III, and Stage I on II and III.

- Near-bottom dissolved oxygen concentrations would be similar at stations within the disposal site compared to stations within the reference areas.

2.0 METHODS

2.1 Bathymetry and Navigation

The precision navigation required for all field operations was provided by the SAIC Integrated Navigation and Data Acquisition System (INDAS). This system uses a Hewlett-Packard 9920 series computer to collect position, depth, and time data for real-time navigation and for subsequent data analysis. Positions were determined to an accuracy of ±3 meters from ranges provided by a Del Norte Trisponder® System. For the present survey, shore stations were established in Connecticut at known benchmarks at Millstone Point and the New London Lighthouse (SAIC 1985). A detailed description of the navigation system and its operation can be found in DAMOS Contribution No. 60 (SAIC 1989). Quality assurance and quality control procedures utilized throughout this survey are explained in the QA/QC plan for the DAMOS Program (SAIC 1990b).

Depths were determined to a resolution of 3.0 cm (0.1 feet) using an Odom DF3200 Echotrac® Survey Recorder with a narrow-beam 208 kHz transducer. The speed of sound used in depth calculations was determined from water temperature and salinity data measured by an Applied Microsystems CTD probe (see Section 2.3 below). During analysis, raw bathymetric data were corrected for speed of sound in seawater and standardized to Mean Low Water by compensating for transducer depth and changes in tidal height during the survey. However, the acoustic records could reliably detect changes in depth on the order of only 20 cm or more due to the accumulation of errors introduced by the positioning system, tidal corrections, the calibration of the fathometer (speed of sound through the water column), the slope of the bottom, and the vertical motion of the vessel. A detailed discussion of the bathymetric analysis technique was given in DAMOS Contribution No. 60 (SAIC 1989).

The bathymetric survey conducted at the New London Disposal Site on 28 June, 6 July, and 9 July 1990 encompassed a 1600 × 1600 m grid with 25 m lane spacing, centered at coordinates 41°16.235′ N and 72°04.492′ W (Figure 1-2). This was the same grid used for the bathymetric survey in July–August 1988, permitting depth differences to be calculated relative to the 1988 survey. The coordinates of the disposal buoy during the present survey were 41°16.450′ N and 72°04.260′ W, placing it approximately 100 m northeast of its location during the February 1989 capping survey (Figure 1-2). Depth difference calculations at the NL-TR mound were done by extracting the appropriate data from the present master survey and comparing the results to the February 1989 survey at the Thames Shipyard and Repair Company disposal mound (SAIC 1990a).

2.2 REMOTS® Sediment-Profile Photography

REMOTS® sediment-profile photographic surveys of the New London Disposal Site have been carried out since June 1984. REMOTS® photography has been used to detect and map the distribution of thin (up to 20 cm) dredged material layers, map benthic disturbance gradients, and monitor the process of infaunal recolonization on and adjacent to the disposal mounds. A detailed description of REMOTS® photograph acquisition, analysis, and interpretative rationale is given in DAMOS Contribution No. 60 (SAIC 1989), and quality assurance and quality control procedures are reviewed in the QA/QC plan for the DAMOS Program (SAIC 1990b).

The REMOTS® stations occupied during the present survey were centered at the NL-TR buoy position described above. Sampling was conducted along a star-shaped grid consisting of 25 stations arrayed at 100 m intervals around a central station (Figures 1-2 and 2-1). In addition to the center station, 4 stations each were positioned to the north, south, east, and west, and 2 stations each in the northeast, northwest, southeast, and southwest directions. At least three replicate REMOTS® photographs were obtained at each station. Individual stations were named on the basis of distance and direction from a central station (i.e., Station 300S was 300 meters south of Station CTR; Figure 2-1).

Thirteen REMOTS® stations, arranged in a cross-shaped pattern and spaced 100 m apart, were also occupied at four additional locations (Figure 2-1). Three of these areas were reference stations, selected to allow comparisons between ambient and on-site conditions. The fourth was centered on the NL-85 mound (41°16.080′ N and 72°04.230′ W, Figure 1-2). Reference stations were positioned at 41°16.200′ N and 72°06.000′ W (W-REF), 41°16.680′ N and 72°03.400′ W (NE-REF), and 41°16.660′ N and 72°02.000′ W (NLON-REF; Figure 1-1). The results of the present survey were compared with the July–August 1988 survey to define the extent of dredged material deposited during the previous two years' disposal activities and to document any changes in existing mound conditions.

2.3 CTD and Dissolved Oxygen Sampling

Depth gradients of temperature and salinity were sampled at selected REMOTS® stations using a Conductivity, Temperature, and Depth (CTD) probe (Applied Microsystems Model STD-12). The operation of this instrument is described in DAMOS Contribution No. 66 (SAIC 1990c). A Yellow Springs Instruments (YSI) dissolved oxygen probe with stirrer was mounted on the CTD and operated with the YSI Model 58 dissolved oxygen meter. The calibration and operation of the YSI oxygen probe are described in YSI (1982).

At selected REMOTS® stations, dissolved oxygen (DO) was measured by titration of a water sample. In these cases, a Niskin bottle was used to obtain water samples from

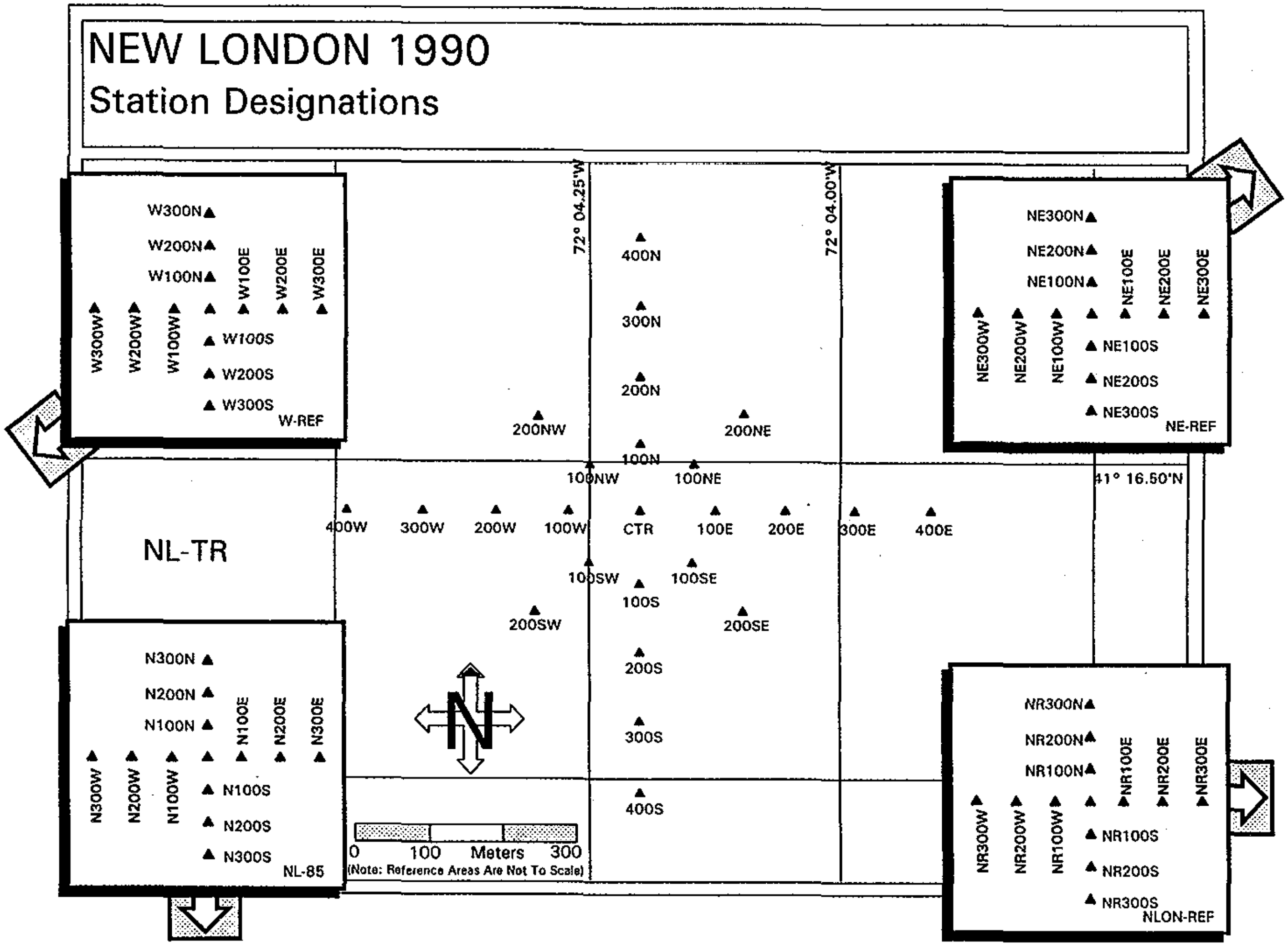


Figure 2-1. Map of New London Disposal Site and reference stations REMOTS® locations

approximately one meter above the bottom. A 300 ml subsample was drawn from the bottle, preserved, and titrated within 12 hours using a modification of the standard Winkler titration method (Strickland and Parsons 1972, Parsons et al. 1984). The original intent of this sampling was to provide an *in situ* check on the YSI dissolved oxygen probe. However, during water-column profiling the YSI probe consistently failed at depth, and therefore only the results of the Winkler titrations were reported for the bottom oxygen concentrations. Surface oxygen values from the YSI probe were considered reliable because the sensor was calibrated to an air-saturated standard immediately prior to deployment. These values were compensated for *in situ* salinity using the CTD results and the algorithm of Benson and Krause (1984). When comparing the surface and near-bottom DO values obtained by these two methods it must be kept in mind that there was no calibration between the instruments.

3.0 RESULTS

3.1 Bathymetry

The 1988 and 1990 bathymetric surveys mapped six disposal mounds: NL-RELIC, NL-I, NL-II, NL-III, NL-85, and NL-88 (Figures 3-1 and 3-2). The NL-88 mound was first identified in the 1988 survey approximately 150 m west of NL-85. Since August 1988, an estimated 21,200 m^3 of additional dredged material was released at NL-88 (based on reported barge volumes). The 1990 bathymetric survey identified a new mound, NL-TR (Figure 3-2). The NL-TR mound formed from material released at the 1989 and 1990 buoy locations 150 m northwest of the NL-II mound. This material was released between 25 January and 10 March 1989, and 15 February and 17 June 1990.

A comparison of the bathymetry between the 1988 and 1990 surveys showed considerable changes in bottom topography at the NL-TR mound and smaller depth changes around the NL-88 mound. In the vicinity of the active disposal buoys (Buoy 89 and Buoy 90), NL-TR covered approximately 550 $\times$ 400 m, and had many small peaks ranging from 0.9 m to 1.9 m height (Figures 3-3 and 3-4). The NL-88 mound covered an area 175 $\times$ 125 m and had gained 1.2 m in mound height since the 1988 survey (Figures 3-3 and 3-5). The mound heights at most of the inactive disposal mounds (NL-RELIC, NL-I, NL-II, and NL-III) were unchanged since the 1988 survey. The NL-85 mound gained approximately 40 cm in height between 1988 and 1990 (Figure 3-5).

Volume calculations based on the bathymetric survey indicated that 46,710 m^3 $\pm$ 14,920 m^3 (95% C.I.) of sediment have accumulated at the NL-TR disposal mound between the July–August 1988 survey and the present. During this same period, barge logs showed an estimated deposition volume of 100,270 m^3. Volume calculations from the vicinity of the NL-88 mound (which included the NL-85 mound) indicated that 11,560 m^3 $\pm$ 2,220 m^3 (95% C.I.) have accumulated in this area of the disposal site since the 1988 master survey. Barge reports for the same region and time period showed that approximately 21,200 m^3 was deposited at the mound.

3.2 REMOTS® Sediment-Profile Photography

Recently deposited dredged material was identified in the central region of the REMOTS® survey over the NL-TR mound. This material typically consisted of poorly sorted sand overlying fine-grained mud (Figure 3-6[A]). The boundaries of this deposit were roughly 200 m west and north of the central station, and 300 m to the east. The southern boundary of the dredged material deposit at NL-TR extended beyond the NL-TR REMOTS® grid (Figure 3-7). The thickness of the surface sand layer at NL-TR stations varied across the mound and even within station replicates. At Station CTR, replicate

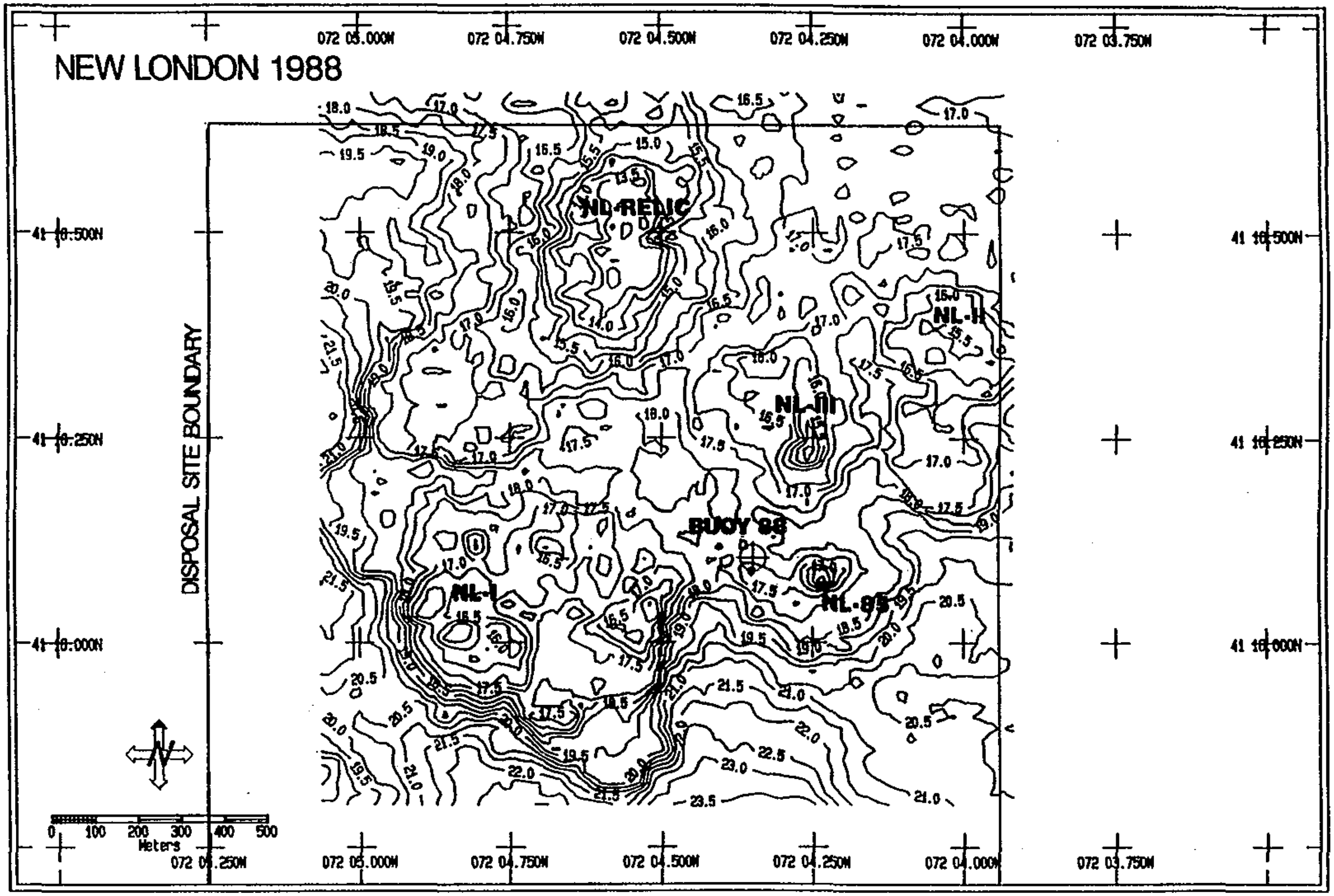


Figure 3-1. Contoured bathymetric chart of the New London Disposal Site (depths in meters) with relic disposal mounds and buoy position, August 1988

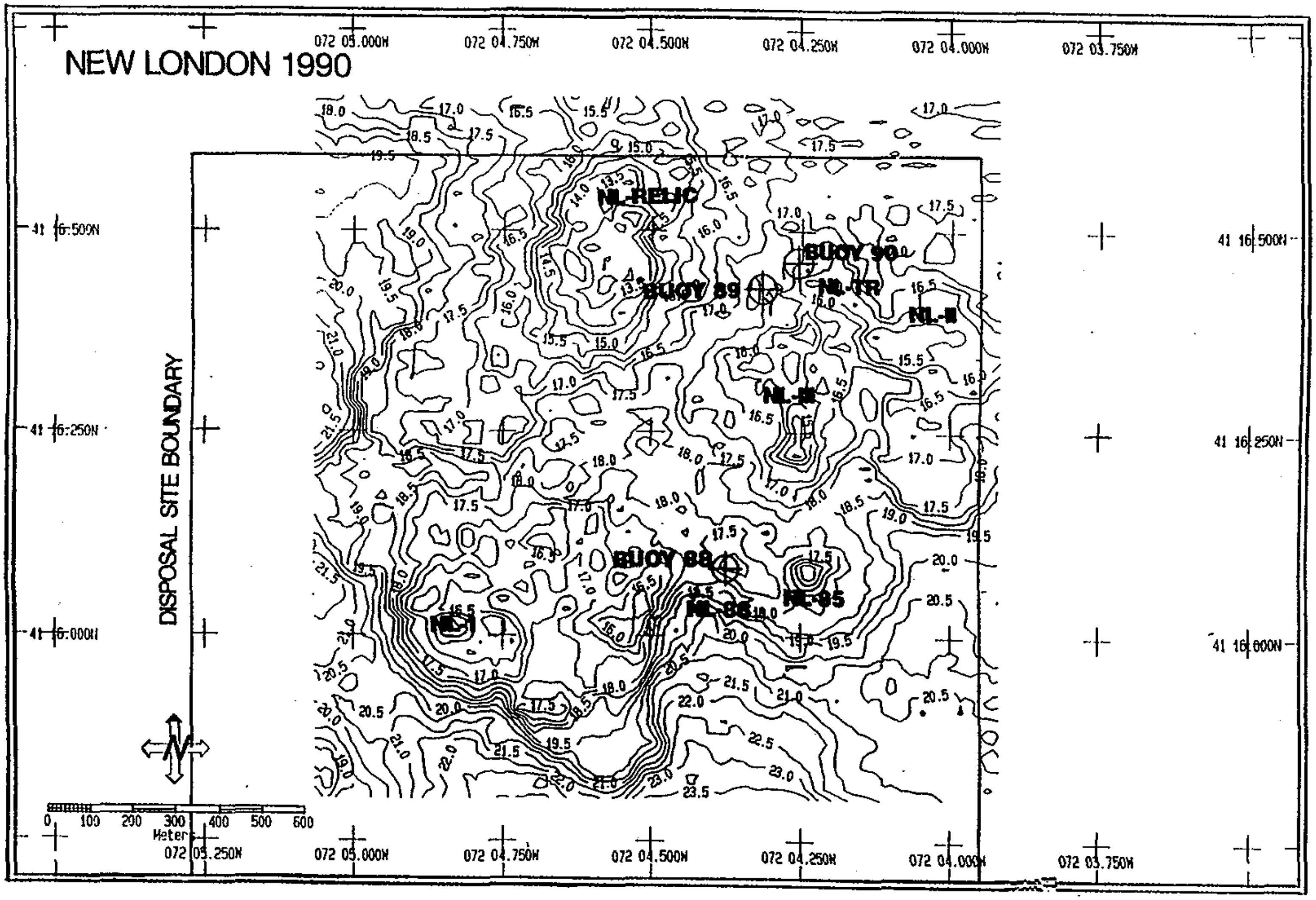


Figure 3-2. Contoured bathymetric chart of the New London Disposal Site (depths in meters) with current and relic disposal mounds and buoy positions, July 1990

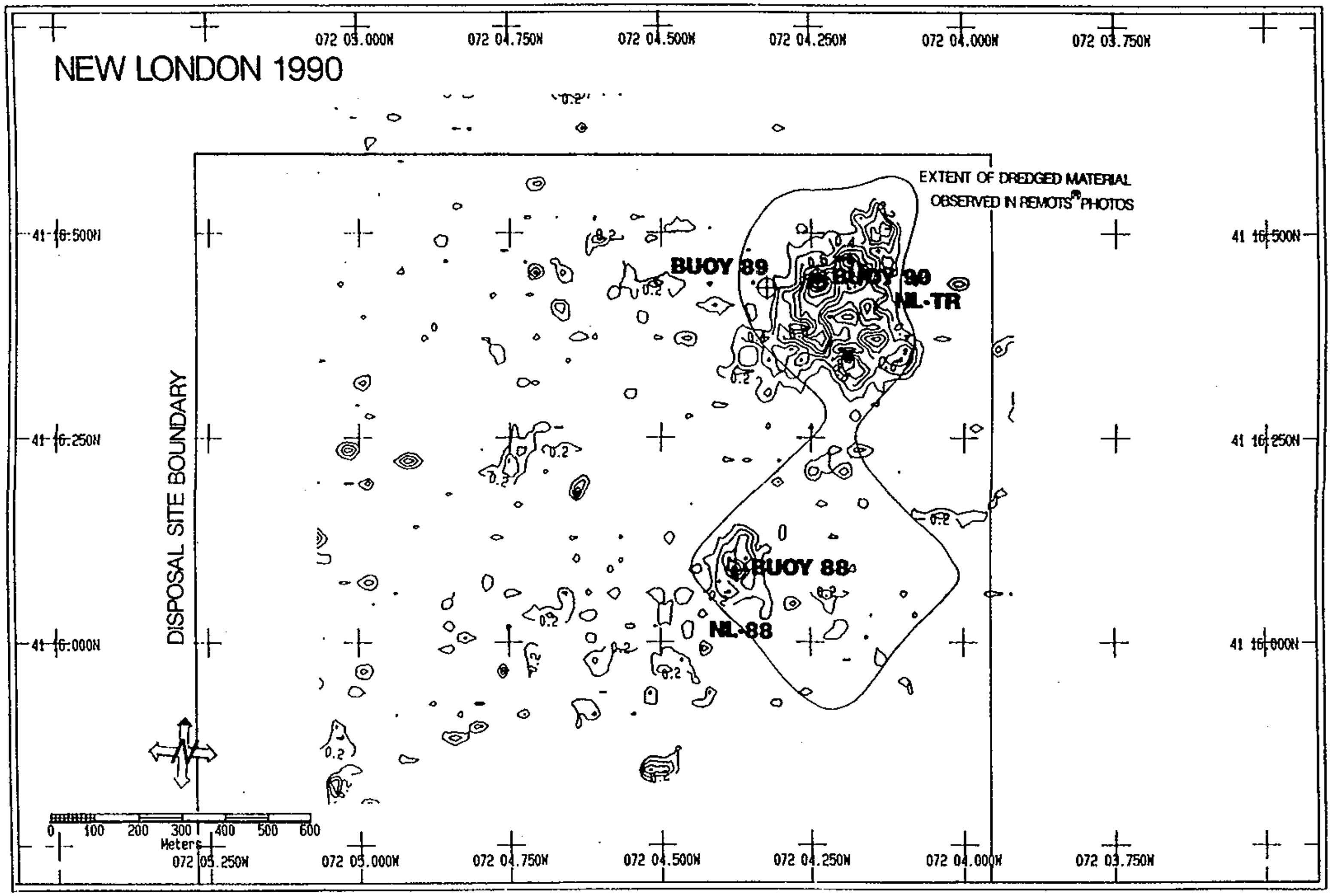


Figure 3-3. Depth difference (in meters) contour map based on comparison of the August 1988 and July 1990 precision bathymetric surveys at the New London Disposal Site. Areal extent of dredged material identified in REMOTS® photographs is outlined.

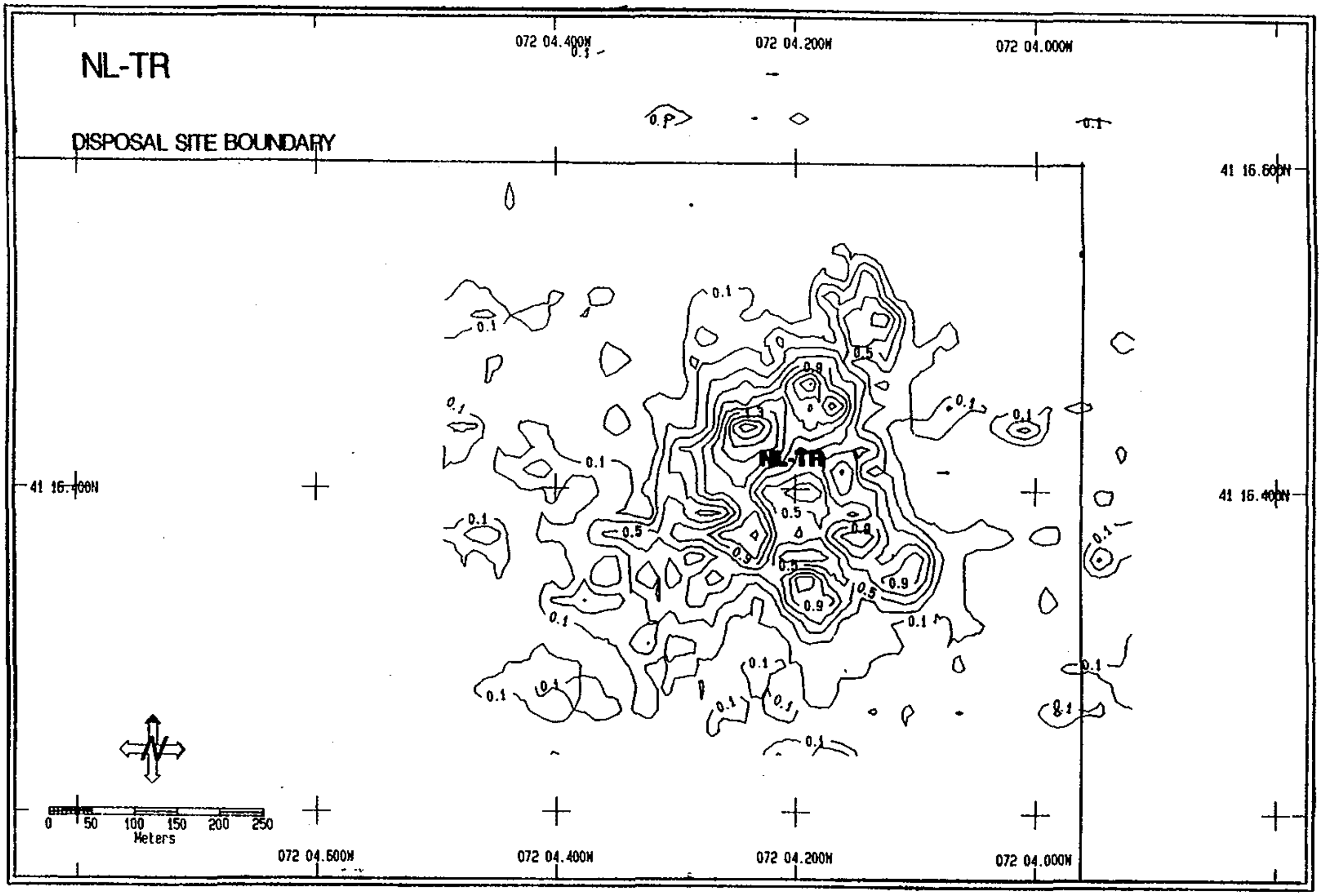


Figure 3-4. Depth difference (in meters) contour map based on comparison of the August 1988 and July 1990 precision bathymetric surveys in the vicinity of the NL-TR mound, New London Disposal Site

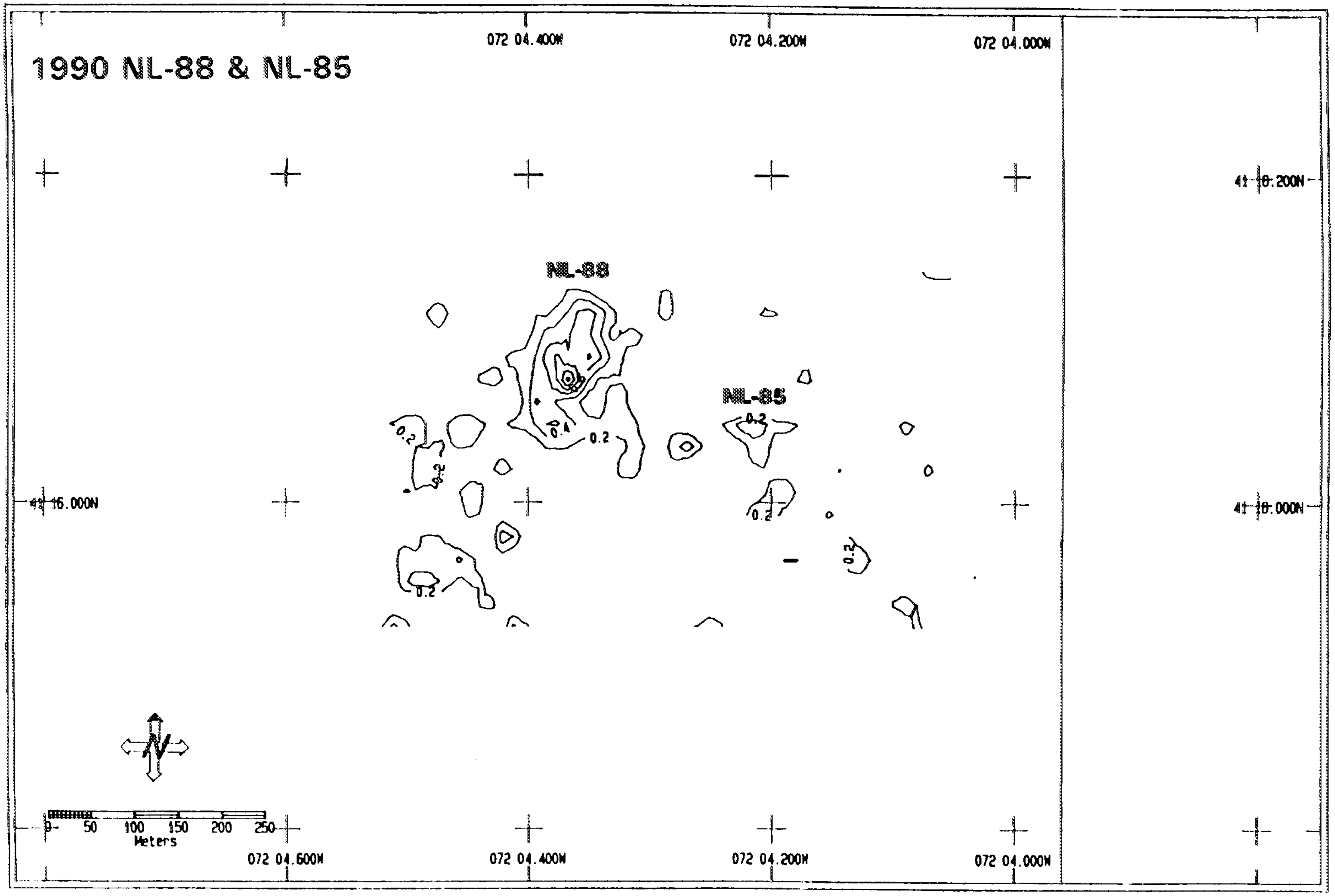
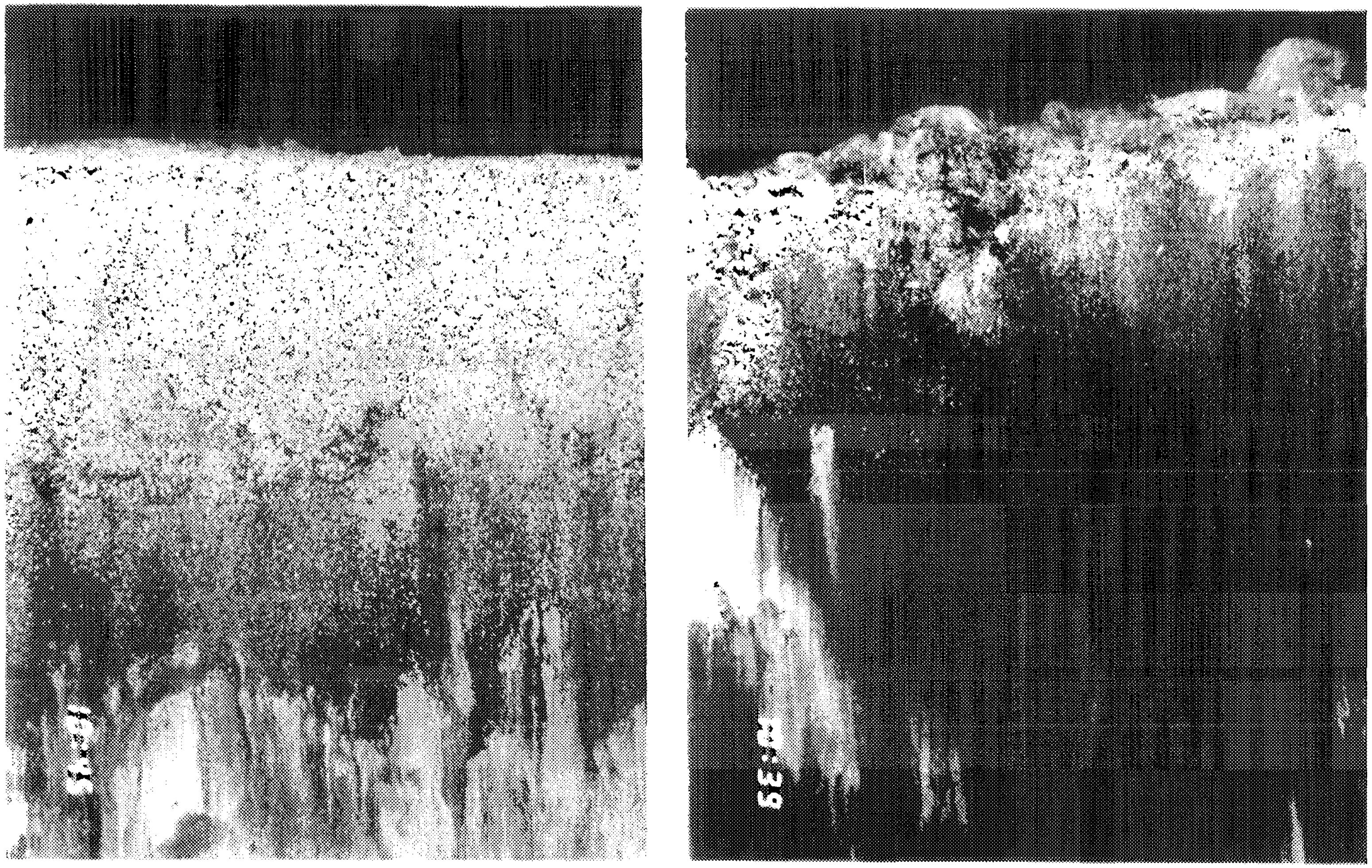


Figure 3-5. Depth difference (in meters) contour map based on comparison of the August 1988 and July 1990 precision bathymetric surveys in the vicinity of the NL-88 and NL-85 mounds, New London Disposal Site



A B

Figure 3-6. REMOTS® photographs of dredged material at Station CTR. A. Photograph of typical dredged sand-over-mud, with relic RPD present, Station CTR. B. Second replicate at same station, but showing reduced mud extending nearly to the surface.

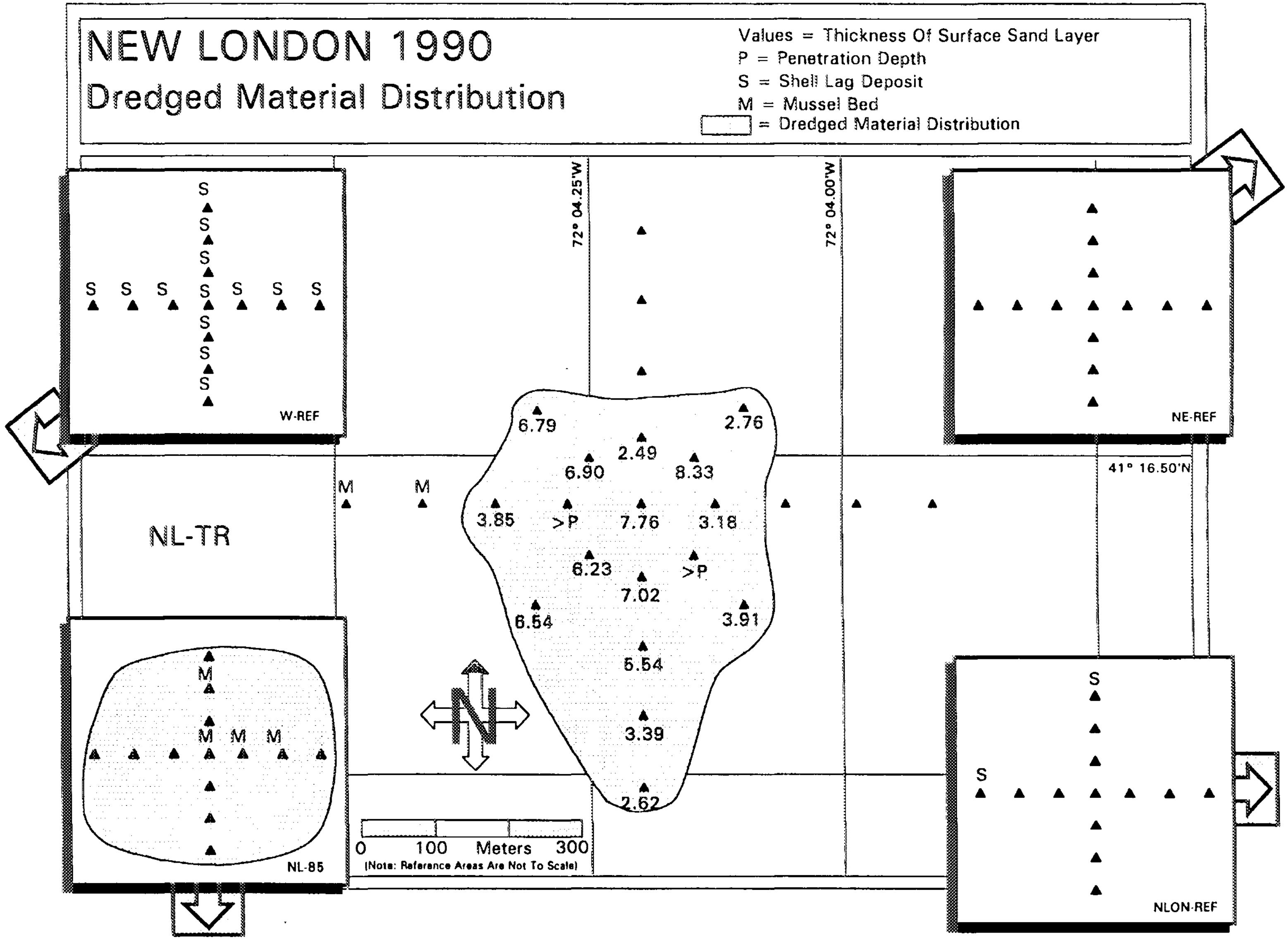


Figure 3-7. Distribution map of dredged material, surface sand thickness, and unique station characteristics at the New London Disposal Site and reference stations

photographs taken only 12 m apart showed a thick oxidized sand layer in one and highly reduced muds extending nearly to the surface in the second (Figure 3-6[A] and 3-6[B]). Although the thickness of the surface sand layer varied, it was greatest at the center station (7.76 cm; Figure 3-7). At most stations over the NL-TR mound, the thickness of the dredged material layer exceeded prism penetration.

In addition to the NL-TR mound, dredged material was identified in all stations of the REMOTS® survey centered on the NL-85 mound (Figure 3-7). As at the NL-TR mound to the north, sand-over-mud was the dominant dredged material stratigraphy. At the NL-85 mound, relic dredged material with presumably fresh overlying sand was present at Station N100N and along the southern and western portions of the cross-grid survey (Figures 2-1, 3-7). At Station N300N, which is close to the 400S station of the NL-TR REMOTS® grid, the poorly sorted sand overlying mud probably derived from disposal at the NL-TR mound (Figure 3-8).

The sediment grain size major mode across the active disposal region (NL-TR) consisted of either fine sands (3-2 phi) or very fine sands (4-3 phi; Figure 3-9). The only exception to this was Station 100SW, where medium sands (2-1 phi) were predominant. Similarly, at the NL-85 mound, sediment grain size major modes were either 3-2 phi or 4-3 phi (Figure 3-9). The one station (N100W) which exhibited coarser grained sediment (2-1 phi) was also affiliated with dredged material. All dredged material was characterized by poorly sorted sands overlying mud. Patches of densely aggregated mussels (Figures 3-7 and 3-10) were also frequently present on the mounds, particularly in the western region of NL-TR and the southern, eastern, and northern areas of NL-85.

The reference areas were not substantially different in grain size distribution from stations on the disposal mounds. At the northeast reference area (NE-REF) and the New London reference area (NLON-REF), grain sizes were almost uniformly 3-2 phi, with only two or three stations in either region exhibiting a major mode of 4-3 phi. Grain sizes were coarser (2-1 phi) over most of the western reference area (W-REF), with the exception of the northern and central stations, which were 3-2 phi. All stations at W-REF were characterized by large amounts of shell fragments and low camera penetration (Figure 3-11).

The mean boundary roughness (the difference between the maximum and minimum prism penetration of the REMOTS® camera) of the NL-TR and NL-85 mounds on the disposal site was 2.11 cm ($s = 1.22$ cm). Roughness values were highest in the central and western regions of the NL-TR mound, and in the central, northern, and western areas of the NL-85 mound (Figure 3-12). The mean boundary roughness of all stations on the disposal site was significantly different from the mean for the pooled reference areas ($p = 0.005$, Mann-Whitney U-test). An important contributor to the increased boundary roughness at the disposal site was the presence of dense mussel aggregations at several stations in the NL-TR

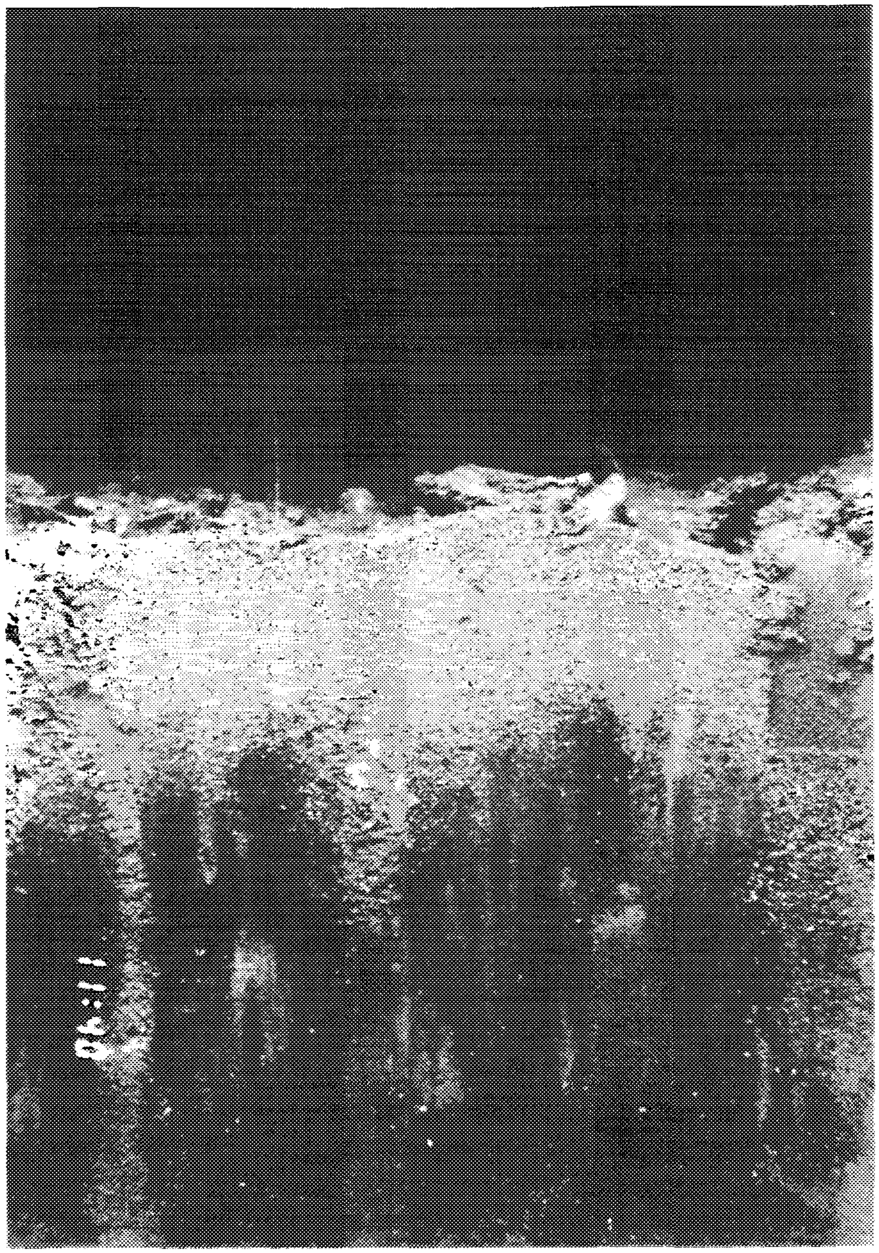


Figure 3-8. REMOTS® photograph at NL-85, Station N300N, showing poorly sorted sands overlying muds

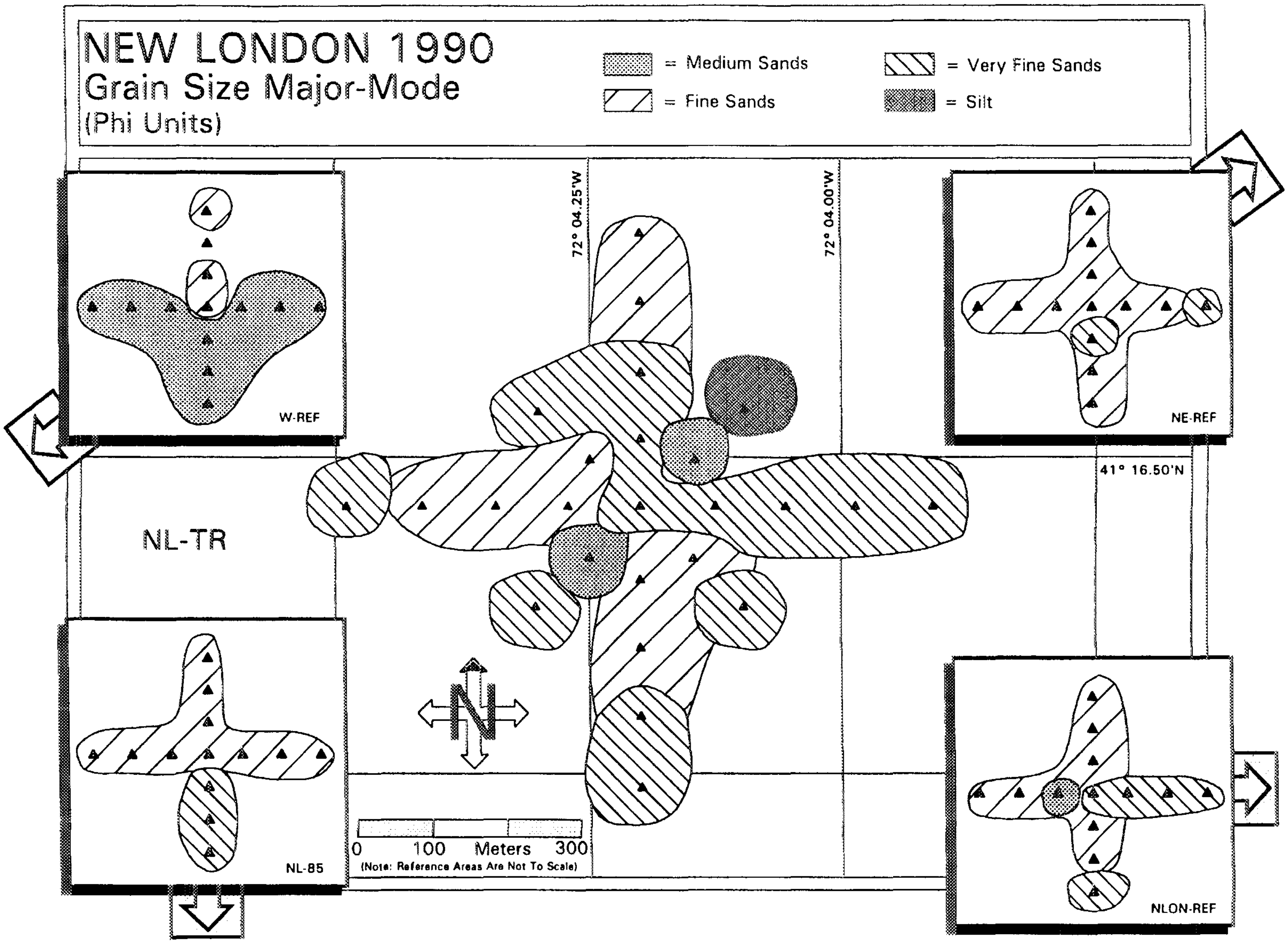


Figure 3-9. Distribution map of median grain size major mode at the New London Disposal Site and reference stations

Figure 3-10. REMOTS® photograph of dense mussel aggregation at Station N200E

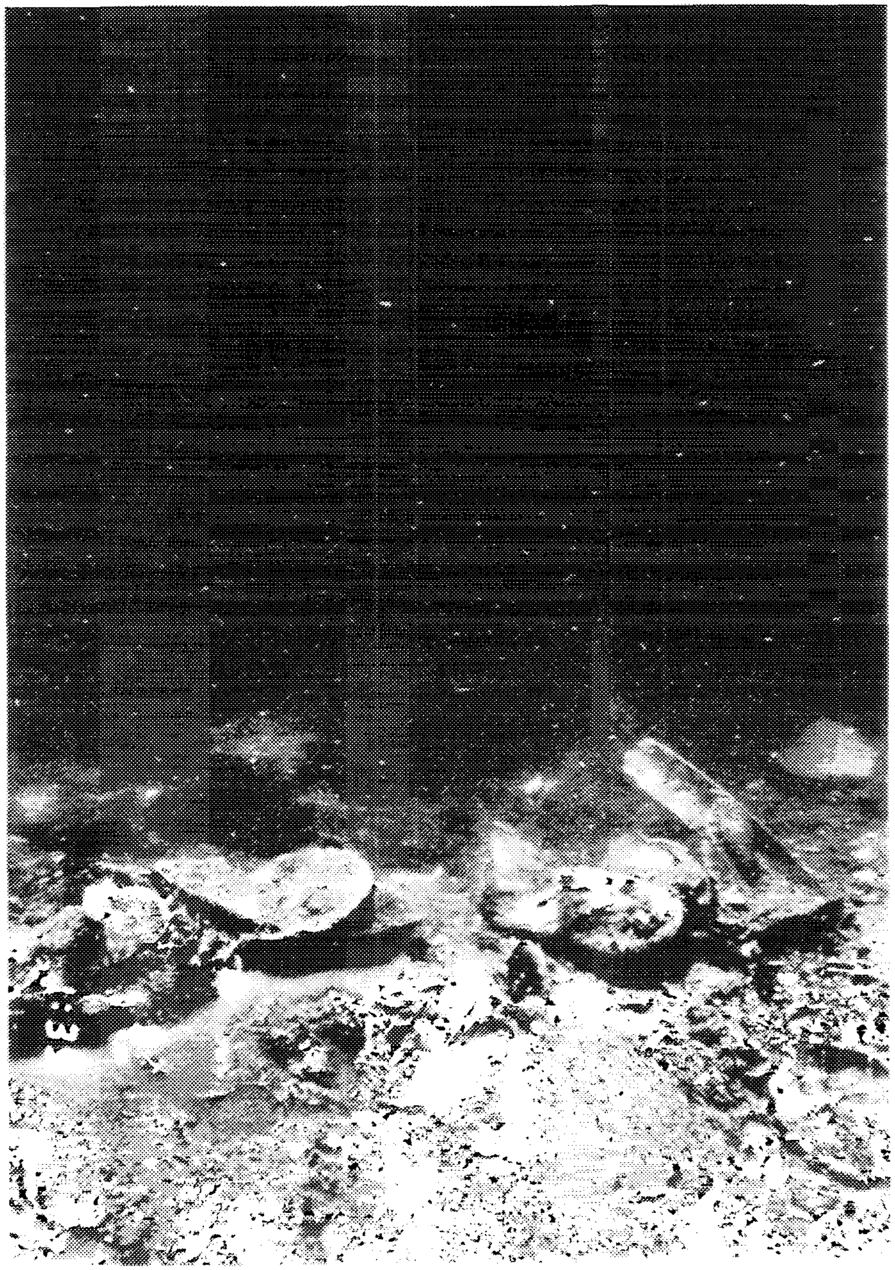


Figure 3-11. REMOTS® photograph of typical station at W-REF (WCTR) showing characteristic low penetration and large amount of shell fragments

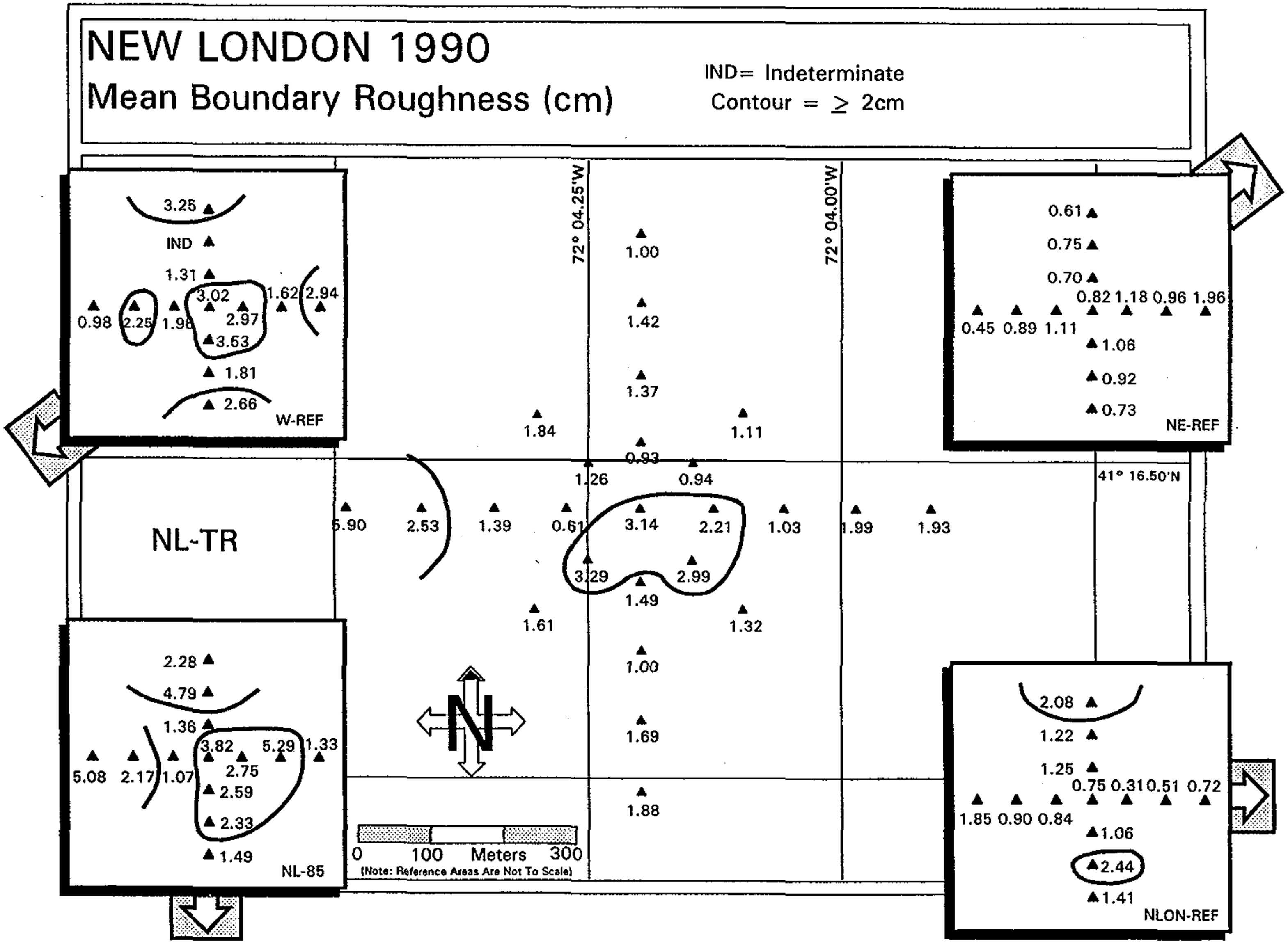


Figure 3-12. Distribution map of mean boundary roughness at the New London Disposal Site and reference stations

and NL-85 REMOTS® grids (Figures 3-7 and 3-10). The frequency distributions for boundary roughness values indicated that the majority of disposal site stations were in the 1-1.5 cm class interval, whereas stations in the reference areas were largely in the 0.5-1 cm class interval (Figure 3-13).

The mean apparent Redox Potential Discontinuity (RPD) depth on the disposal site was 4.28 cm (s = 1.25 cm), which was greater than the mean RPD depth of the pooled reference stations (3.50 cm, s = 1.19 cm). The difference between the two areas was statistically significant ($p = 0.027$, Mann-Whitney U-test), although there was no clear pattern of RPD depth distribution over either the NL-TR or NL-85 mounds (Figure 3-14). The frequency distribution of RPD depths at the disposal site indicated that the majority of values were evenly divided between the 3, 4, and 5 cm class intervals whereas reference station RPD depths fell principally in the 3 to 4 cm categories (Figure 3-15).

Stage II and Stage II on III taxa dominated the successional series present at the NL-TR disposal mound (Figure 3-16). Likewise, the NL-85 mound also consisted of principally Stage II and Stage II on III, although some Stage I and Stage I on III taxa were present in the central region of the mound. Reference areas NE-REF and NL-REF were similar in successional sere to the NL-TR mound, with most stations being either Stage II or Stage II on III. The western reference area, W-REF, was largely indeterminate due to low camera penetration. At the few stations with sufficient penetration, Stage III and Stage II on III were the only series evident. These were observed in the central and western stations of W-REF.

Based on results of past REMOTS® surveys, Organism-Sediment Index (OSI) values of +6 or less are considered indicative of chronically stressed benthic habitats and/or those which have experienced recent disturbance (e.g., erosion, dredged material disposal, hypoxia, intense demersal predator foraging, etc.; Rhoads and Germano 1986). For the present survey, median OSI values ranged from +6.5 to +11 on the disposal site mounds and from +5 to +11 across the three reference areas (Figure 3-17). On the NL-TR and NL-85 mounds, the most frequently occurring value was +11, but at the reference stations +9 was the most frequent (Figure 3-18). However, there was no significant difference in median OSI values between the disposal site and reference stations ($p = 0.865$, Mann-Whitney U-test). The lowest OSI values at the NL-TR mound were distributed unevenly but tended to be found west and south of the center station. At the NL-85 mound, lower OSI values generally were clustered in the center of the REMOTS® grid (Figure 3-17).

3.3 CTD and Dissolved Oxygen Sampling

On 3 July 1990, near-bottom (1 m above the bottom) oxygen concentrations were uniformly 8.3 $mg \cdot l^{-1}$ at both the disposal site mounds and the three reference areas (Table 3-1). Although temporal comparisons were not truly valid from single point-in-time readings, these measurements were consistent with oxygen values of 5.3 to 8.3 $mg \cdot l^{-1}$

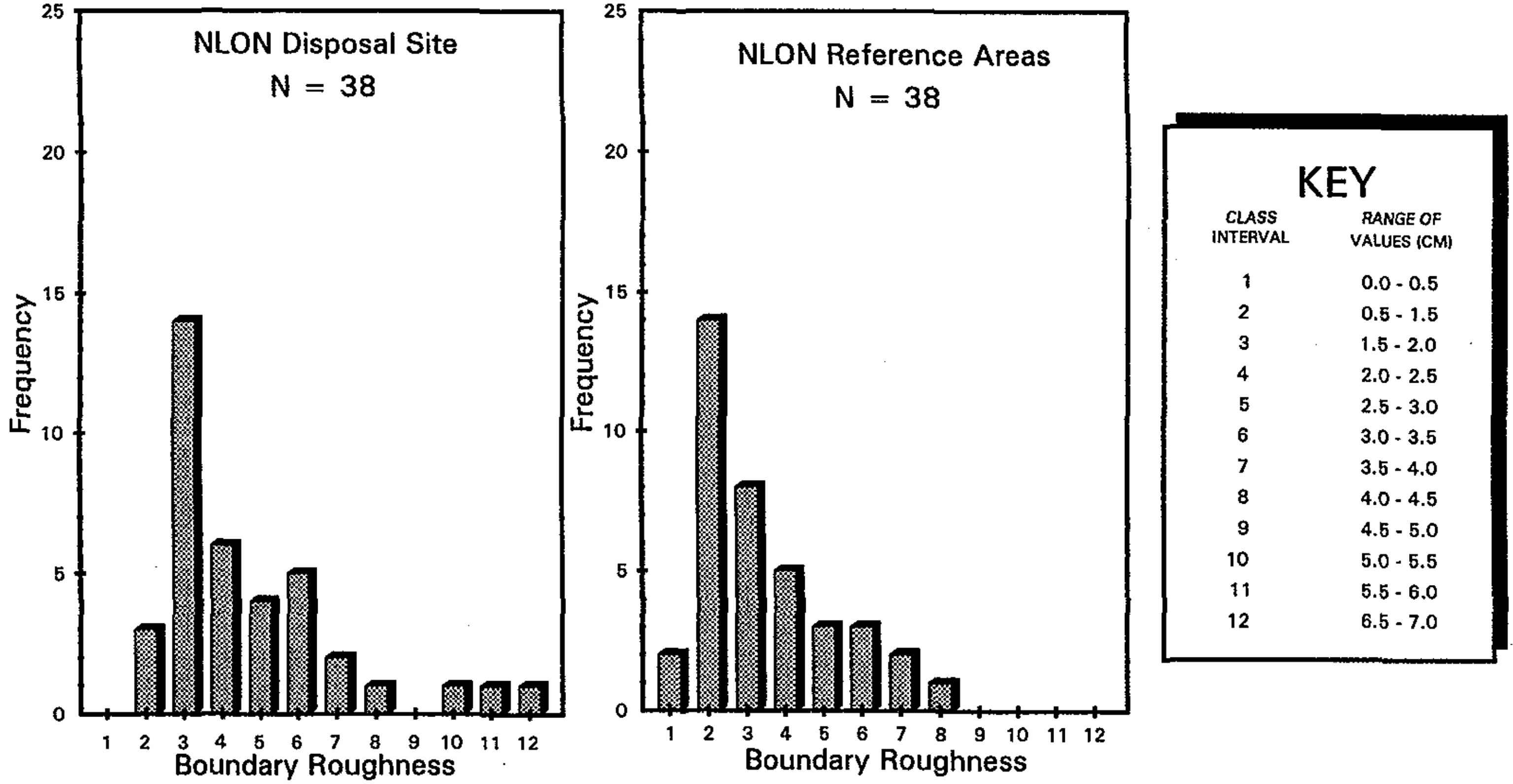


Figure 3-13. Frequency distribution of mean boundary roughness values at the pooled disposal site (both the NL-85 and NL-TR mounds) and the reference stations

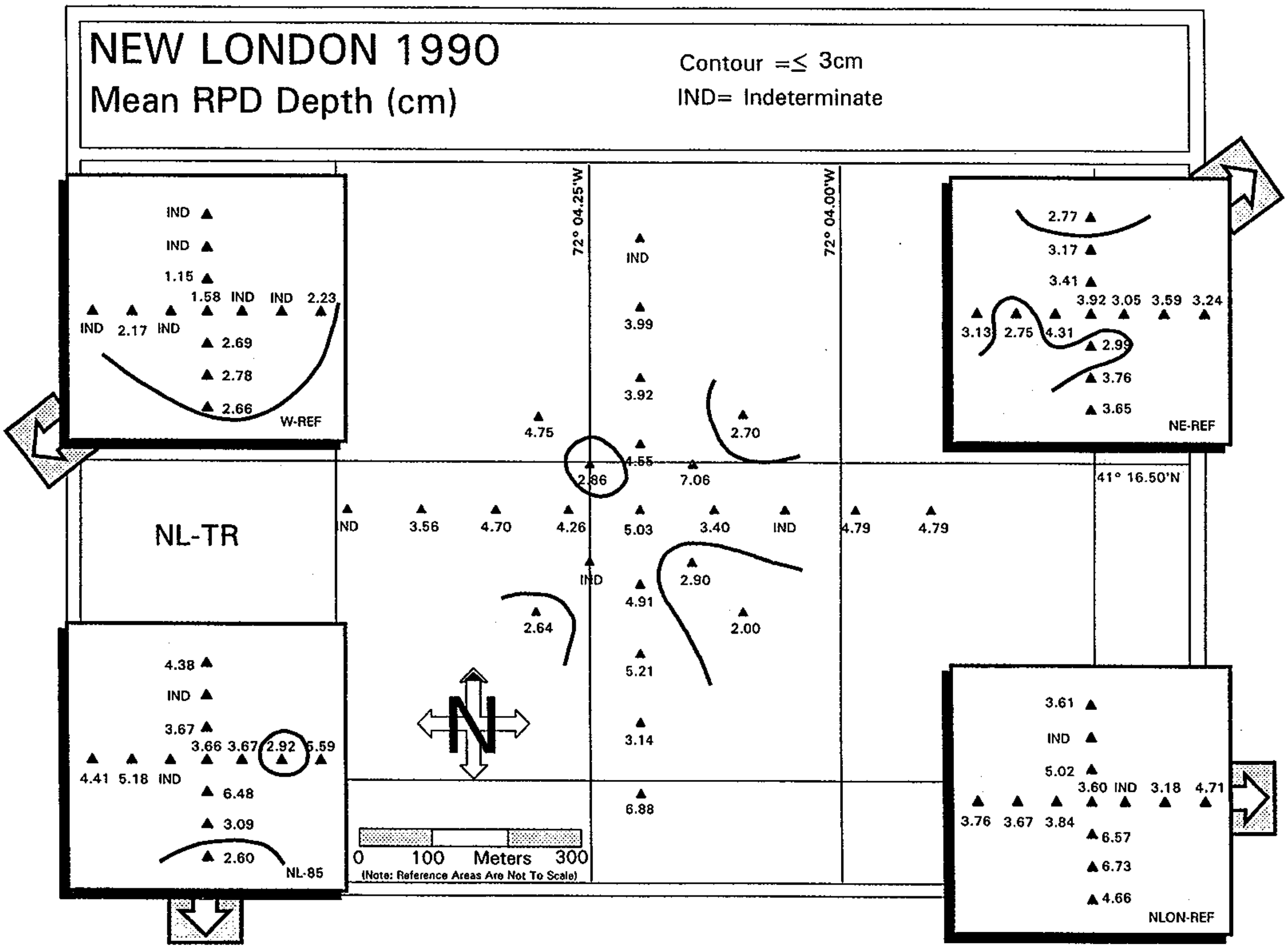


Figure 3-14. Distribution map of mean apparent RPD depths at the New London Disposal Site and reference stations

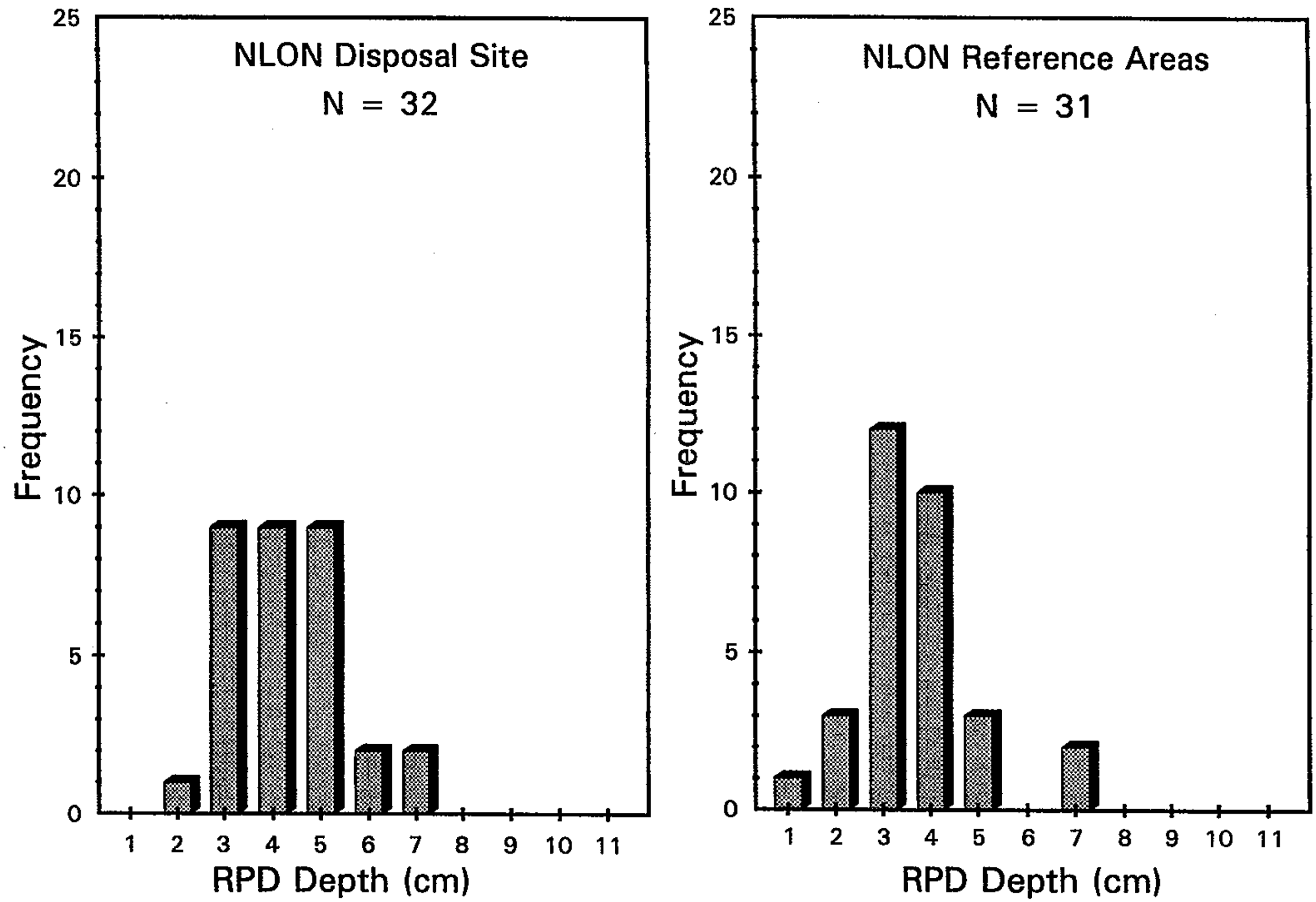


Figure 3-15. Frequency distribution of mean apparent RPD depths at the pooled disposal site (both NL-85 and NL-TR mounds) and reference stations

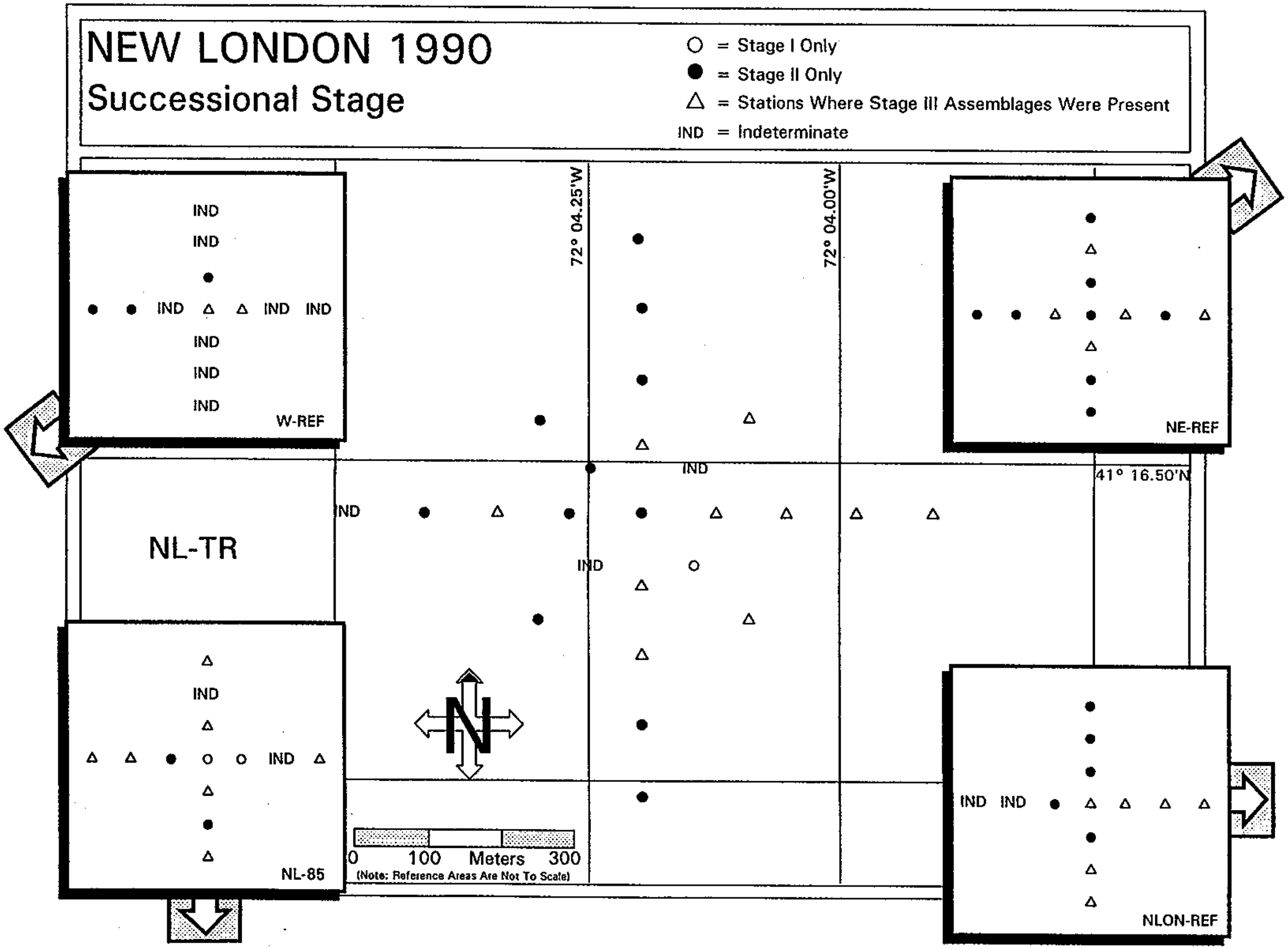


Figure 3-16. Distribution map of successional stages at the New London Disposal Site and reference stations

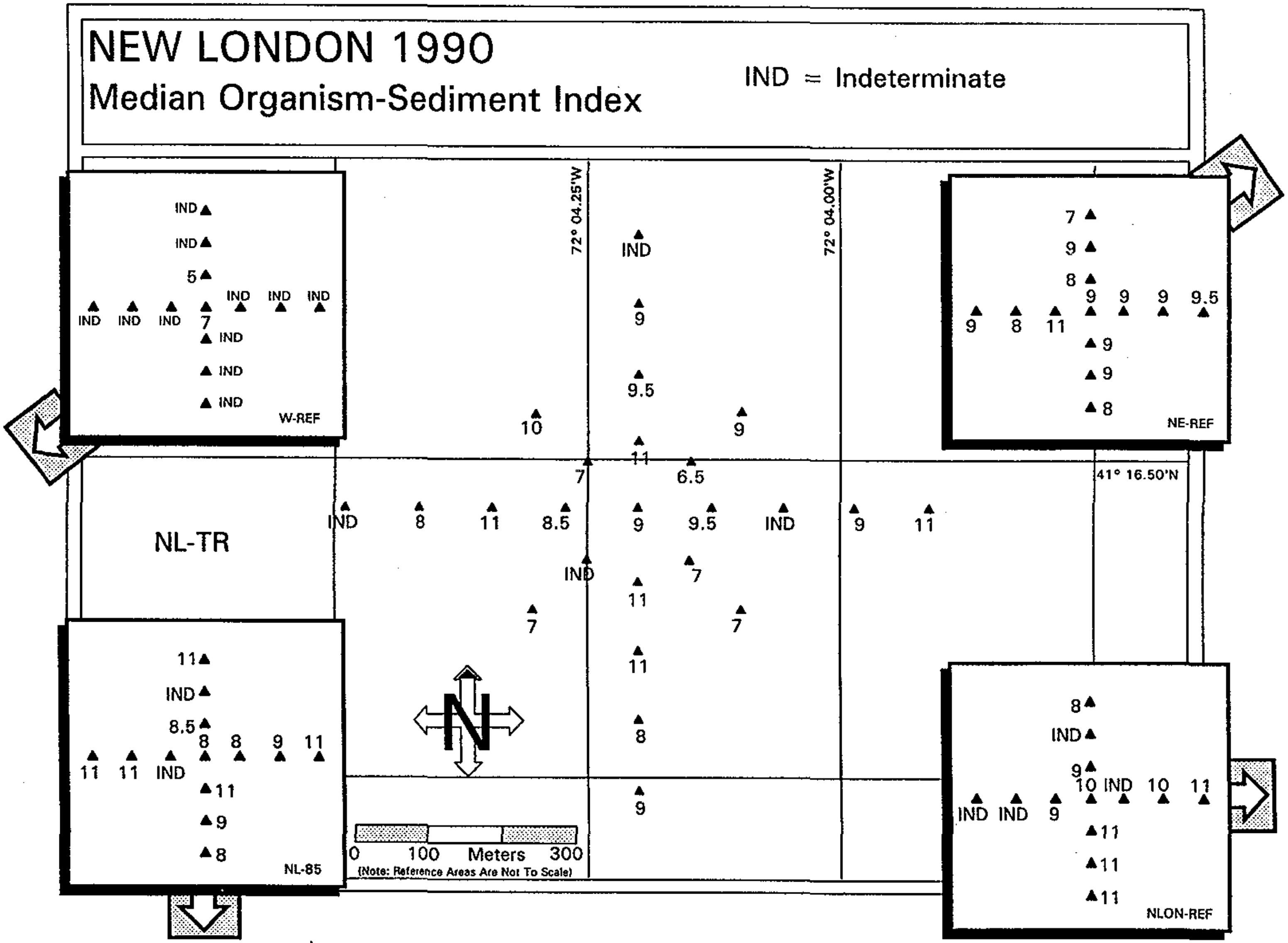


Figure 3-17. Distribution map of median Organism-Sediment Index (OSI) values at the New London Disposal Site and reference stations

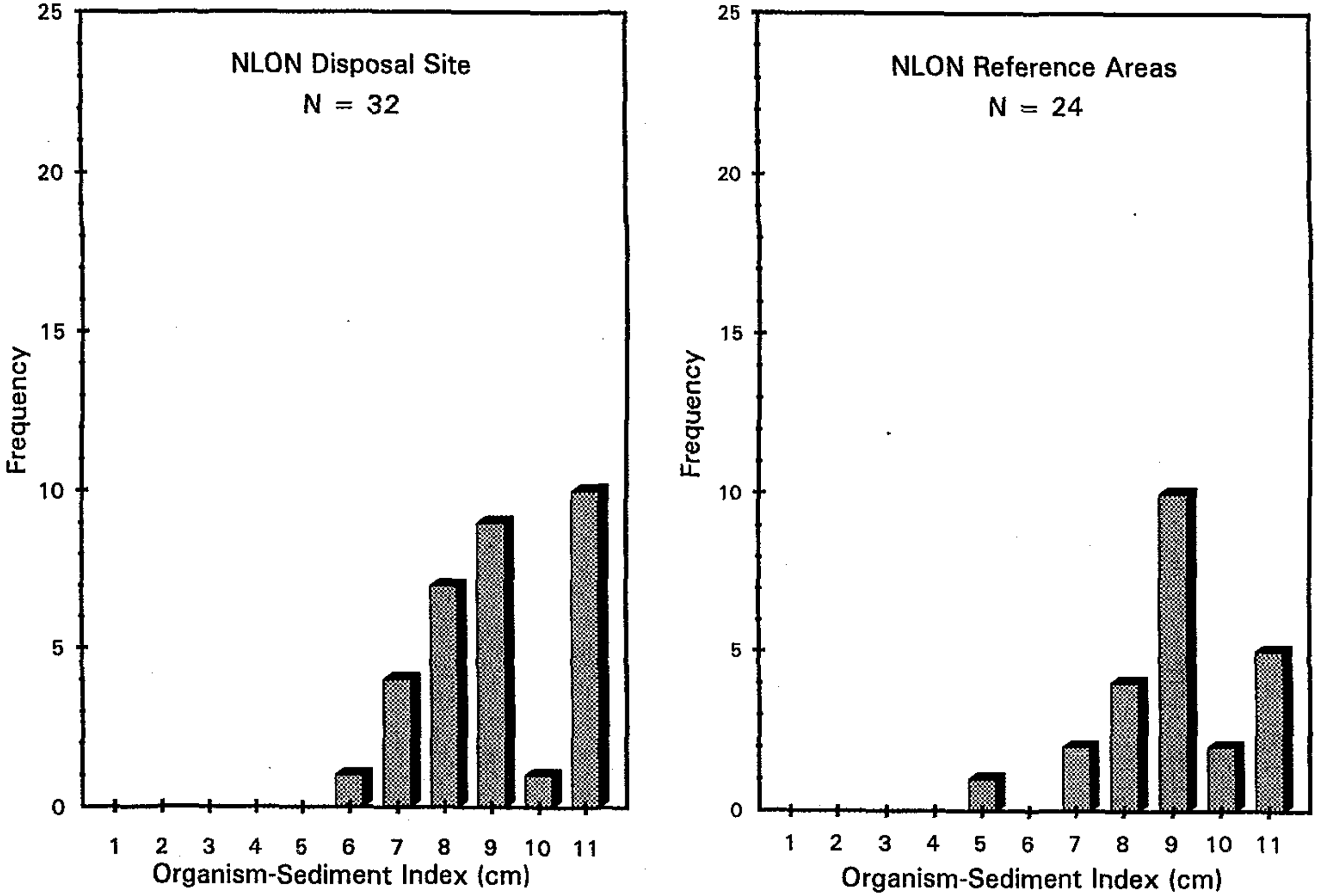


Figure 3-18. Frequency distribution of median Organism-Sediment Index (OSI) values at the New London Disposal Site and reference stations

Table 3-1

Dissolved Oxygen Concentrations ($mg \cdot l^{-1}$)
at NLON and Reference Stations, July 1990

Station	Surface[1]	Bottom[2]
NLON-REF	7.6	8.3
NE-REF	8.6	8.3
W-REF	8.4	8.3
NL-85	8.4	8.3
NL-TR (Center)	7.7	8.3
NL-TR (West)	8.1	-
NL-TR (South)	8.4	-
NL-TR (East)	8.1	-
NL-TR (North)	7.9	-

[1] Measured with YSI oxygen meter
[2] Measured by Winkler titration

recorded in the same area during the July–August 1988 survey. Surface oxygen measurements made with a YSI dissolved oxygen meter were slightly more variable but nearly identical to bottom oxygen concentrations. Surface values for all profiles ranged from 7.6 to 8.4 $mg \cdot l^{-1}$, with an average concentration of 8.1 $mg \cdot l^{-1}$ ($s = 0.3$ $mg \cdot l^{-1}$; Table 3-1).

Plots of depth gradients in temperature, salinity, and density (sigma-t) are given in the Appendix. CTD profiles at both the disposal site and the reference stations showed only a slightly stratified water column, with a broad pycnocline existing between 4 to 10 m deep. Mean bottom temperature of all profiles was 16.09° C ($s = 0.12°$ C), which was slightly cooler and less variable than the mean surface temperature of 17.32° C ($s = 0.40°$ C; Table 3-2). Concomitant with the small thermal gradient, salinity and sigma-t did not change greatly over the depth of the water column. For all parameters, surface waters were slightly more variable than bottom waters, and surface-to-bottom gradients were small (Table 3-2, and see Appendix).

Table 3-2

Summary of CTD Profile Data
(Temperature, Salinity, and Sigma-t)

	Mean	Standard Deviation
Surface Temperature	17.32	0.40
Bottom Temperature	16.09	0.12
Surface Salinity (ppt)	31.07	0.24
Bottom Salinity (ppt)	31.76	0.17
Surface Sigma-t	22.44	0.27
Bottom Sigma-t	23.25	0.16

4.0 DISCUSSION

Since the October 1988 monitoring survey at the New London Disposal Site, additional cap material has been released at the NL-TR mound, and additional dredged material has been released at the 1988 buoy location to the south. The precision bathymetric survey detected material deposited since the last survey in 1988 that exceeded the resolution of the bathymetric system (greater than 20 cm). The REMOTS® survey detected the areal extent of new material below the resolution of the bathymetric survey. This survey was also used to determine the status of recolonization at the inactive NL-85 mound. Near-bottom dissolved oxygen concentrations were assessed relative to REMOTS® benthic analyses at and near the disposal site.

4.1 NL-TR Disposal Mound

The NL-TR mound, located in the northeastern region of New London near the 1989 and 1990 buoy locations, has an area of 550 m × 400 m and had gained up to 2 m of material since October 1988. These dimensions were obtained by comparing the 1988 and 1990 bathymetric surveys (Figure 3-4) and were confirmed by the distribution of dredged material in REMOTS® photographs (Figure 3-7).

Bathymetric profiling at NL-TR did not show a single, conical mound but rather a series of small peaks overlapping at their flanks and forming an irregularly shaped region of new material (Figure 3-4). This complex topography was the result of capping operations at NL-TR. Because dredged material was disposed over a wide region (six points instead of one), the predicted mound radius of 250-300 m underestimated the footprint of dredged material. The volume of dredged material at NL-TR based on barge logs was approximately 100,300 m^3. This represented the total amount of material deposited since the 1988 survey and included both the original sediment from the Thames Shipyard and Repair Company dredging operations and the cap material deposited since October 1988. The volume calculated by comparing the NL-TR region of the 1990 and 1988 bathymetric surveys was 46,700 m^3, or about a 53% reduction from the volume recorded in the barge logs (100,300 m^3).

Some of this volume difference (53,600 m^3) can be attributed to the wide distribution of disposal points and the significant volume of material deposited along the margins of the six mounds in layers less than the 20 cm acoustic detection limit. In addition, loss of interstitial water as the material settles on the bottom, and consolidation of dredged material and ambient bottom will have contributed to the volume difference. These estimates are in relatively good agreement with the results of Tavolaro (1984) who calculated an average of 41% reduction in volume between barge volume estimates and measured disposal mound volumes.

The effectiveness of the capping operation at NL-TR was assessed by comparing the depths in the October 1988 (postdisposal, precapping) survey with the same region after capping in February 1989 and July 1990 (Figures 4-1 and 4-2). The original postdisposal survey recommended that cap material be deposited at locations A-F (SAIC 1988; Table 1-1) to fully cover the material associated with dredging activities at the Thames Shipyard and Repair Company. The postcapping survey in February 1989 was not able to detect a sufficiently thick layer (between 50 and 100 cm; SAIC 1990a; Figure 4-1) of new material at stations "A", "B", and "F". Despite deposition of an additional 39,483 m^3 of cap material between 13 March and 17 June 1990, the July survey results indicate that locations "A" and "F" do not display the minimum 50 cm of cap material over the eastern one third of the project area (Figure 4-2). The depth difference values must be considered minimum thicknesses as the ambient and disposed material under the cap will have consolidated after placement, reducing the measured difference.

The postcapping survey found that cap material had formed seven distinct mounds (SAIC 1990a) rather than a uniform cover over the area. No disposal buoys were deployed to mark the individual locations. Only the LORAN-C navigation system was used to guide all disposal barges to designated discharge points. LORAN-C utilizes a series of highly repeatable time delay signals (TDs) to calculate positions. As the capping operation proceeded, barges discharged at the same location several times, eventually forming the irregular bottom topography. If a wider variety of discharge points was utilized, it is possible that the cap material would have been spread more evenly over the area.

Benthic recolonization at NL-TR was predicted to be at Stage I in the central portion of the mound, while the margins were expected to exhibit Stage II, III, and Stage I on II and III. For the most part this prediction was correct, although there were more Stage II than Stage I assemblages present in the center of the mound (Figure 3-16). Stage II represents a transitional sere between Stages I and III and is associated with recovery of a disturbed benthic habitat (Rhoads and Germano 1986). REMOTS® photographs taken at the margins of the mound showed the presence of Stage II and Stage III assemblages, as predicted. Organism-Sediment Indices were generally high (+7 or greater) across the mound, indicating a lack of severe benthic disturbance (Figure 3-17). Among the assemblages present at the western edge of NL-TR were large beds of blue mussels (Figures 3-7 and 3-10). These indicate relative stability in the area and correspondingly are found in stations that do not have recent dredged material. These mussels would be excellent candidate species for future bioaccumulation studies (Germano et al. 1994). Analyzing the tissue contaminant level of these suspension feeders would help address some of the concerns about the effectiveness of capping operations for isolating contaminants.

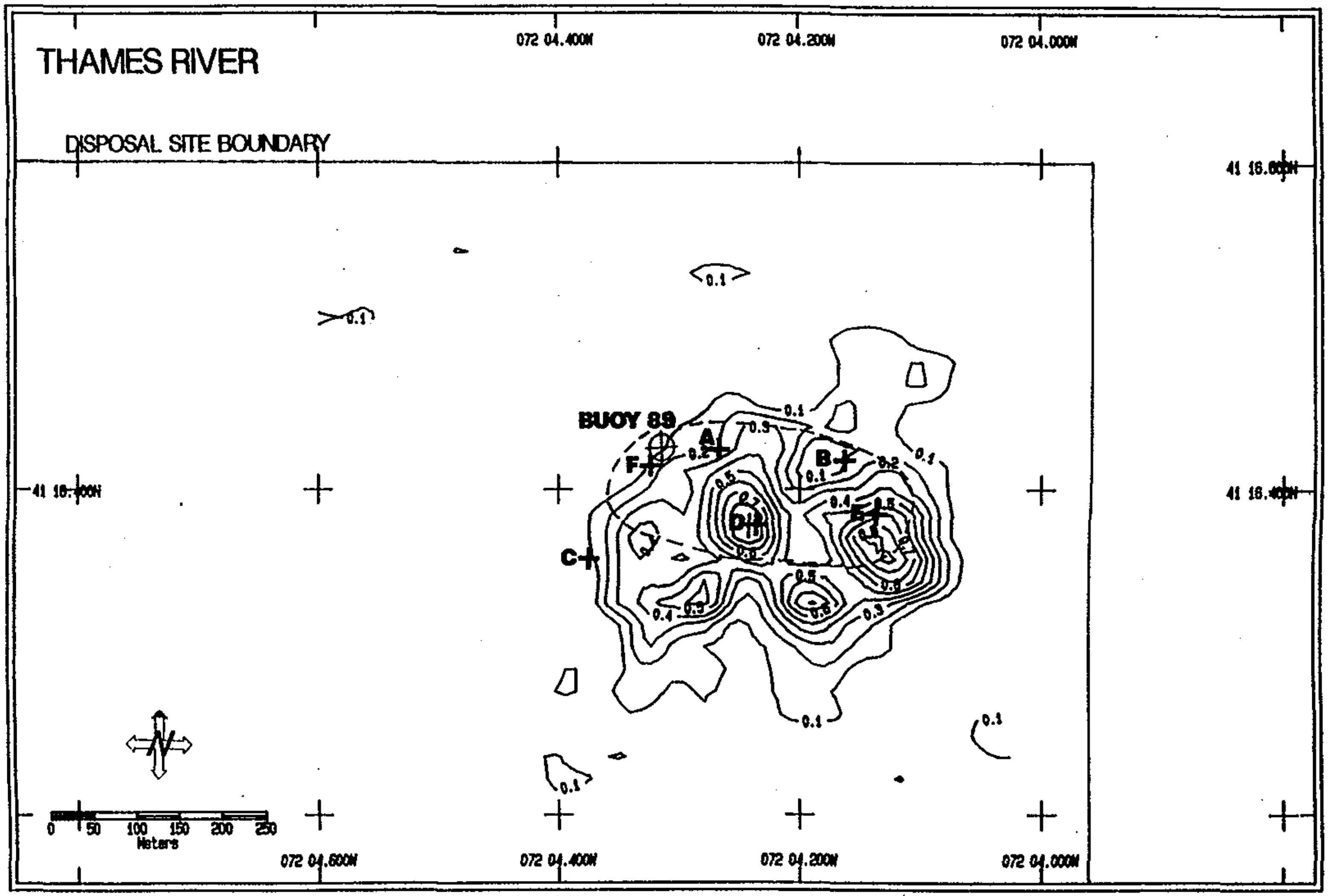


Figure 4-1. Depth difference contour plot of the Thames Shipyard and Repair Company disposal location (NL-TR, depth in meters) showing the distribution of cap material deposited between October 1988 and February 1989. Dashed line indicates areal extent of underlying dredged material initially deposited at this location.

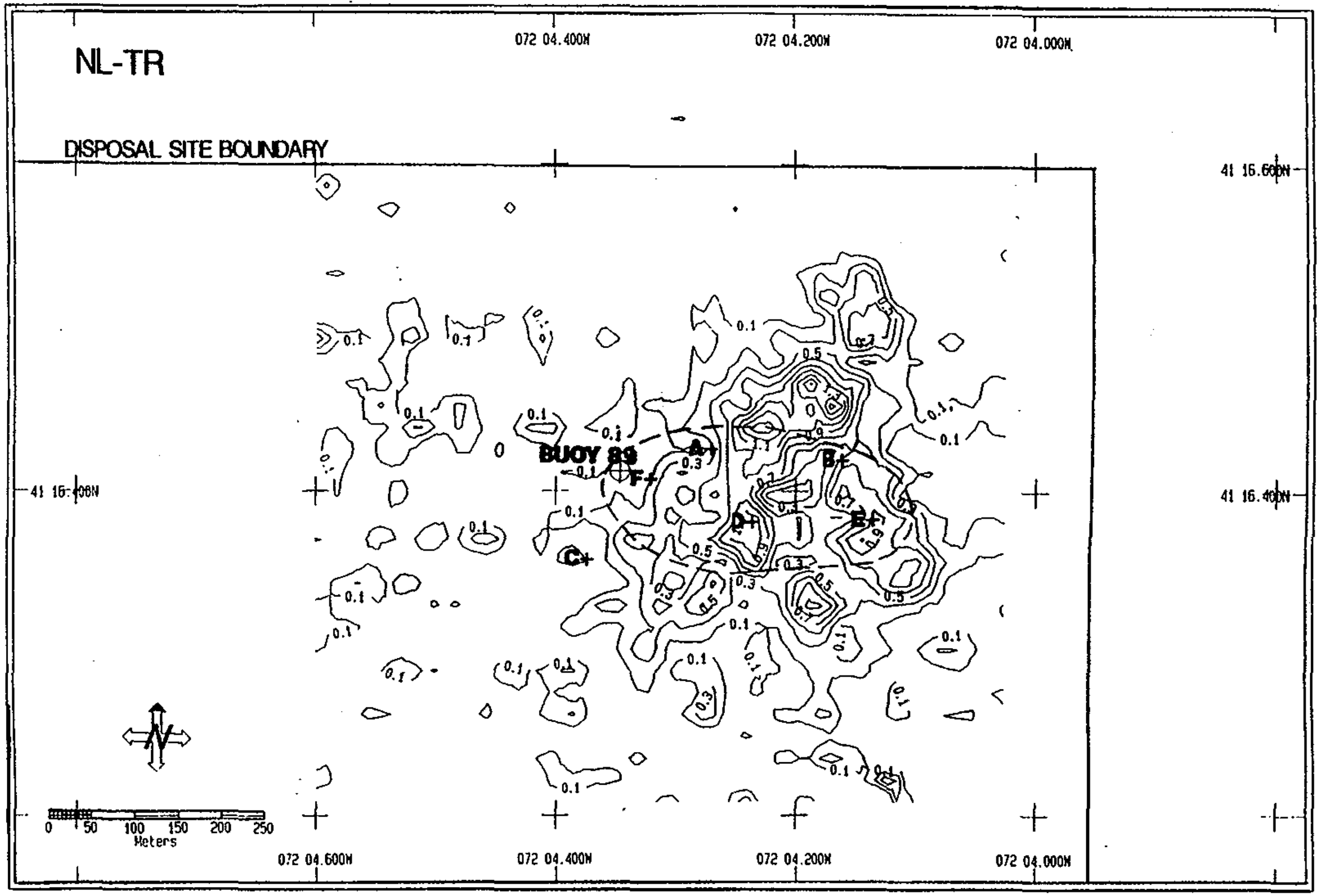


Figure 4-2. Depth difference contour plot (depth in meters) of the Thames Shipyard and Repair Company disposal location (NL-TR) showing the distribution of cap material deposited between October 1988 and July 1990. Positions mark the intended disposal points listed in Table 1-1. Dashed line indicates areal extent of underlying dredged material initially deposited at this location.

4.2 NL-88 and NL-85 Disposal Mounds

The 1990 bathymetric survey detected a disposal mound at the 1988 buoy location. This disposal mound, NL-88, was 1.2 m high at the apex of the mound with dimensions of 175 × 125 m. The mound is centered about 150 m west of the NL-85 mound and was first detected in the 1988 survey (Figure 3-1) (SAIC 1990d). Since that time it has received a relatively small amount of dredged material (21,200 m^3). The sediment volume calculated by subtracting the 1990 and 1988 bathymetric surveys was 11,560 m^3, or about a 45% reduction of the volume reported by disposal logs within the vicinity of the NL-88 mound. This was in relatively good agreement with the results of Tavolaro (1984), who showed that depth difference estimates of disposal volume were approximately 41% lower than barge volume estimates, principally due to compaction, loss of interstitial water, and material in layers too thin to be detected acoustically. As predicted, the mound height at NL-85 (immediately to the west of NL-88) was unchanged since the 1988 survey.

Although dredged material was present at all NL-85 stations, the spatial coverage of the REMOTS® survey was not sufficient to characterize the areal extent of new material in the disposal area, particularly material deposited at NL-88. The 13-station cross-shaped REMOTS® sampling grid was centered on the NL-85 mound, and only the western portion of the survey crossed over the NL-88 mound (Figure 1-2). Additional dredged material, below the resolution detectable with bathymetry, may also have been present to the west, south, and north of the NL-88 mound.

Benthic recolonization at NL-85 was found to be primarily at Stage II and Stage III (as predicted; Figure 3-16). However, at the center of NL-85, Stage I assemblages were present, indicating that this area had probably experienced recent disturbance. The depth difference plot of the 1988 and 1990 bathymetric surveys does indicate that there has been 40 cm of material added to the center of the NL-85 mound since 1988. The northern and eastern arms of the NL-85 REMOTS® survey have mussel beds. This indicates sediment stability and is supported by the lack of sediment accumulation and the absence of barge release points in the area (Figure 4-3). The plot of barge disposal points shows that most of the material intended for the 1988 buoy location was released within 150 m north and west of the NL-88 buoy location.

The plot of barge disposal points also displays 21 positions scattered to the southwest of the NL-TR and NL-88 disposal locations (Figure 4-3). This plot was generated from the LORAN-C TDs provided by the disposal logs. The X-ray (X) and Yankee (Y) secondary stations of the LORAN-C 9960 chain were customarily used for navigation at the New London Disposal Site. However, these 21 points correspond to the plotted Whiskey (W) and Yankee (Y) LORAN-C TDs as reported in the disposal logs of the M/V *Nancy G.* According to these same disposal logs, cap material was discharged in close proximity to Buoy 90 on the NL-TR disposal area. We believe that poor signal geometry of the Whiskey

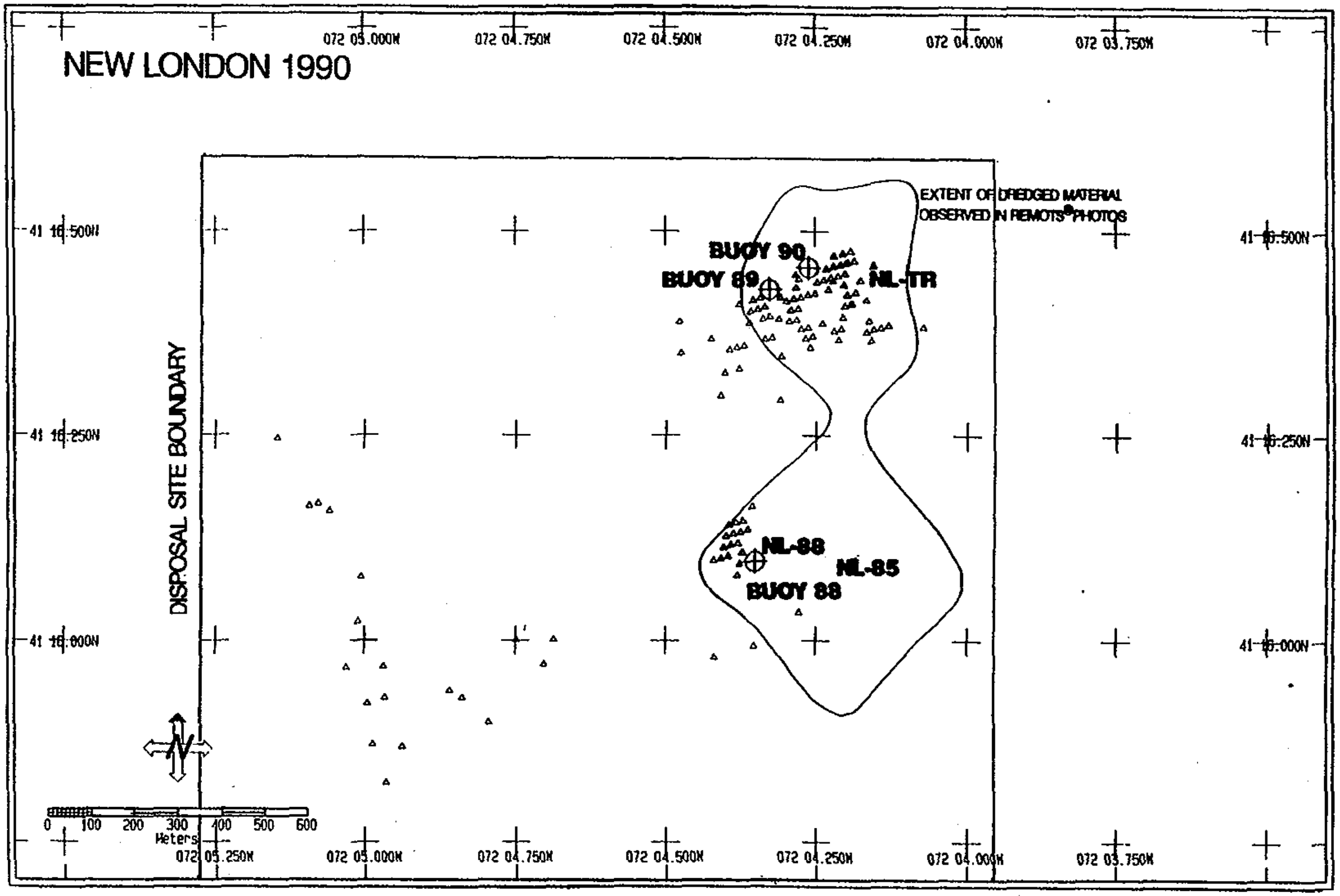


Figure 4-3. Plot of reported barge disposal positions (LORAN-C) between October 1988 and June 1990. Contour line delimits extent of dredged material observed in REMOTS® photographs. The nineteen points scattered to the southwest represent the reported disposal positions of the M/V *Nancy G*. We believe these positions do not represent the actual disposal locations which were reported to be near Buoy 90.

(W) and Yankee (Y) signals or an errant LORAN-C receiver aboard the M/V *Nancy G.* caused inaccurate TD readings, resulting in an apparent offset in the plot (Figure 4-3) of disposal points. These 21 barges represent 36,391 m^3 of cap material that was released between February 14 and March 8, 1990. The dredged material was derived from the Connecticut Department of Transportation Project, during construction of the Baldwin Bridge in the Connecticut River.

Five stations from the 1990 REMOTS® survey at NL-85 were directly comparable to the survey done in August 1988. These stations (N200N, NCTR, N200S, N200W, and N200E) encompassed the central region of the mound. The OSI values and apparent RPD measured at Station N200N were indeterminate in both surveys, so only 4 stations actually could be analyzed. The depth of the mean apparent RPD increased from 3.0 cm in 1988 to 3.7 cm in 1990, and the OSI increased from +8.7 (1988) to +9.3 (1990). These differences were not statistically significant, probably due to the small sample size. Nevertheless, the direction of change in both indicators was consistent with expectations for an area recovering from disturbance.

4.3 Oxygen Concentration and Benthic Habitat Quality

The objective of the CTD/DO sampling was to assess near-bottom dissolved oxygen concentrations at the disposal site and reference stations and to consider these results in relation to benthic habitat conditions at the site. Salinity, temperature, and sigma-t profiles showed little stratification in the vicinity of the New London Disposal Site (see Appendix). In the absence of a strong pycnocline, bottom waters will generally remain well oxygenated. Oxygen concentrations measured 1 m above the bottom at the disposal site, and reference stations were uniformly 8.3 $mg \cdot l^{-1}$. The oxygenated bottom water was consistent with the presence of well-developed oxidized surface layers of sediment at the disposal site and reference stations (Figure 3-14). Surface oxygen concentrations were slightly more variable, ranging from 7.9 to 8.9 $mg \cdot l^{-1}$. The results of the present (1990) survey suggest that oxygen concentrations were uniformly high across the region and confirmed the prediction that oxygen levels would be similar both on and off the disposal site.

5.0 CONCLUSIONS

The results of the bathymetric survey at the New London Disposal Site showed two regions of topographic change relative to the 1988 New London master survey. In the southern region of the survey, the NL-88 disposal mound covered an area 175 × 125 m. The dredged material volume estimated from subtracting the 1988 and 1990 surveys was 11,560 m^3, compared to 21,200 m^3 estimated from barge disposal records for the same area. A REMOTS® survey found dredged material distributed across the entire NL-85 mound; however, the detectable change in mound height relative to the 1988 survey was 40 cm at the center of the mound. Benthic recolonization at NL-85 was substantially as predicted (Stage II and III). Future REMOTS® surveys should be extended to characterize adequately all recent dredged material in the vicinity of both NL-88 and NL-85.

The NL-TR mound was approximately 550 × 400 m with a volume of 46,700 m^3. Since October 1988, material has been deposited at several locations in an effort to cap the mound; therefore, the resulting sediment footprint was more widespread than the predicted radius of 250-300 m. The bathymetric analyses indicate that less than 50 cm of capping material is present at locations "A" and "F". However, it is probable that consolidation and interstitial water loss in the underlying dredged material may have decreased the apparent thickness of the cap and given the appearance that the capping operation at NL-TR did not cover the original mound adequately (Figure 4-2). Locations "A" and "F" (Table 1-2) should receive more clean material as a precaution. To cover these points to an apparent cap thickness of 50 cm, an estimated barge volume of 15,225 m^3 of dredged material is required. In order to cover location "F" completely, disposal operations should be directed to the Buoy 89 position (41°16.430′ N, 72°04.320′ W) and deliver an estimated 7,448 m^3 of new cap material. Location "A" requires an estimated 2,682 m^3 of material at coordinates 41°16.423′ N, 72°04.270′ W, as well as an estimated 5,095 m^3 at coordinates 42°16.384′ N, 72°04.310′ W.

Benthic recolonization at the margins of NL-TR was largely as predicted (Stage II, III and Stage I on II and III). At the mound center some of the predicted Stage I seres were present, but this region was more typically heterogenous, with Stage II, Stage III, and "Indeterminate" stations. This indicates a healthy recovery well within expected recolonization rates and is typical of pulsed disturbance patterns with long intervals.

Near-bottom dissolved oxygen concentrations were uniform at stations both on and off the disposal site (Table 3-1). Little stratification of the water column was present, and bottom waters were well oxygenated on the day of sampling (3 July 1990). The measured oxygen concentrations were nearly identical to conditions observed during the July–August 1988 survey. High oxygen levels in the presence of Stage III taxa and well-developed apparent RPD depths suggested that low oxygen stress had not affected benthic recolonization on the disposal site, at least within several weeks prior to the survey. Similarly, there was no indication that dredged material disposal operations were influencing oxygen concentrations adversely in the region.

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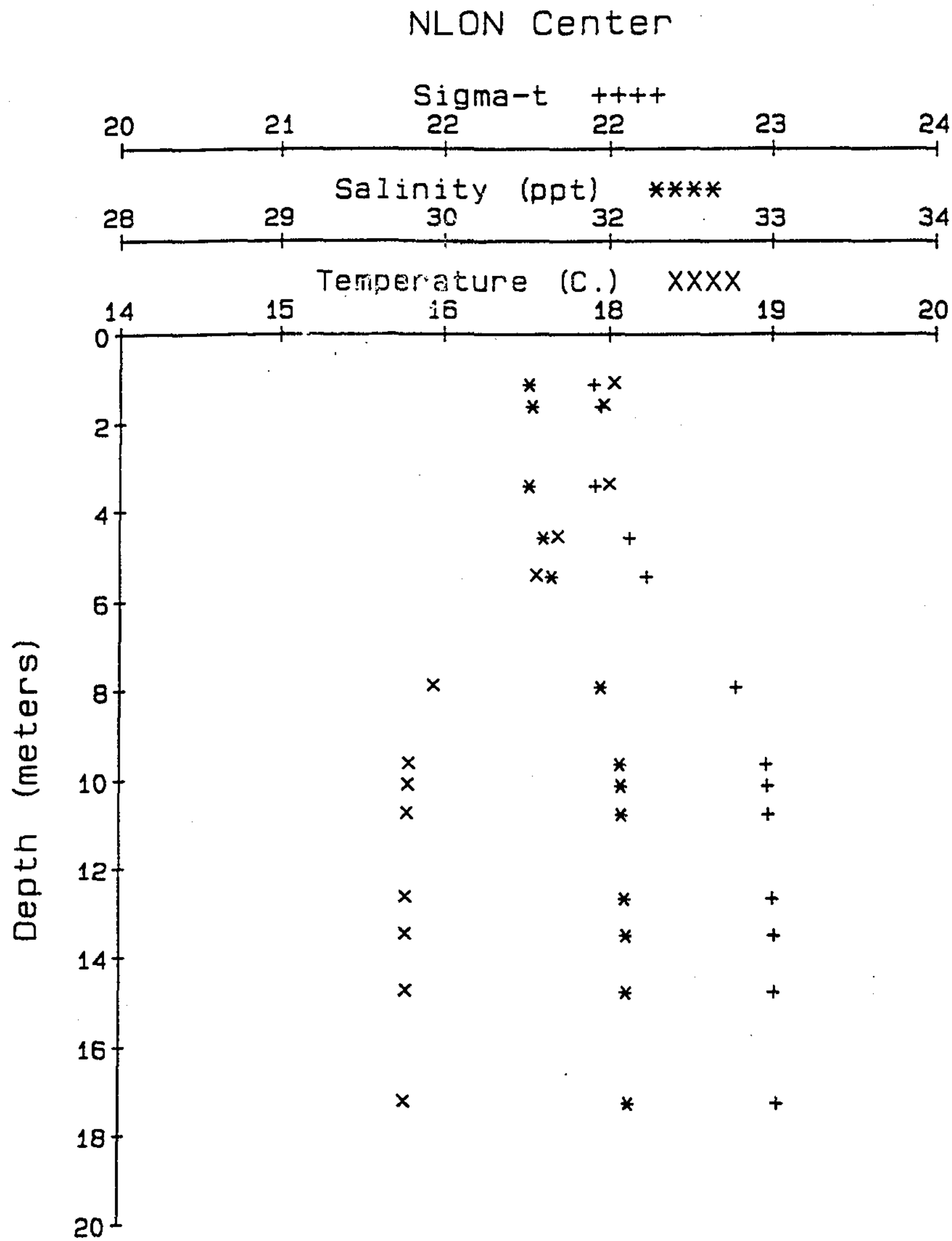
APPENDIX



NLON Center
Sigma-t ++++
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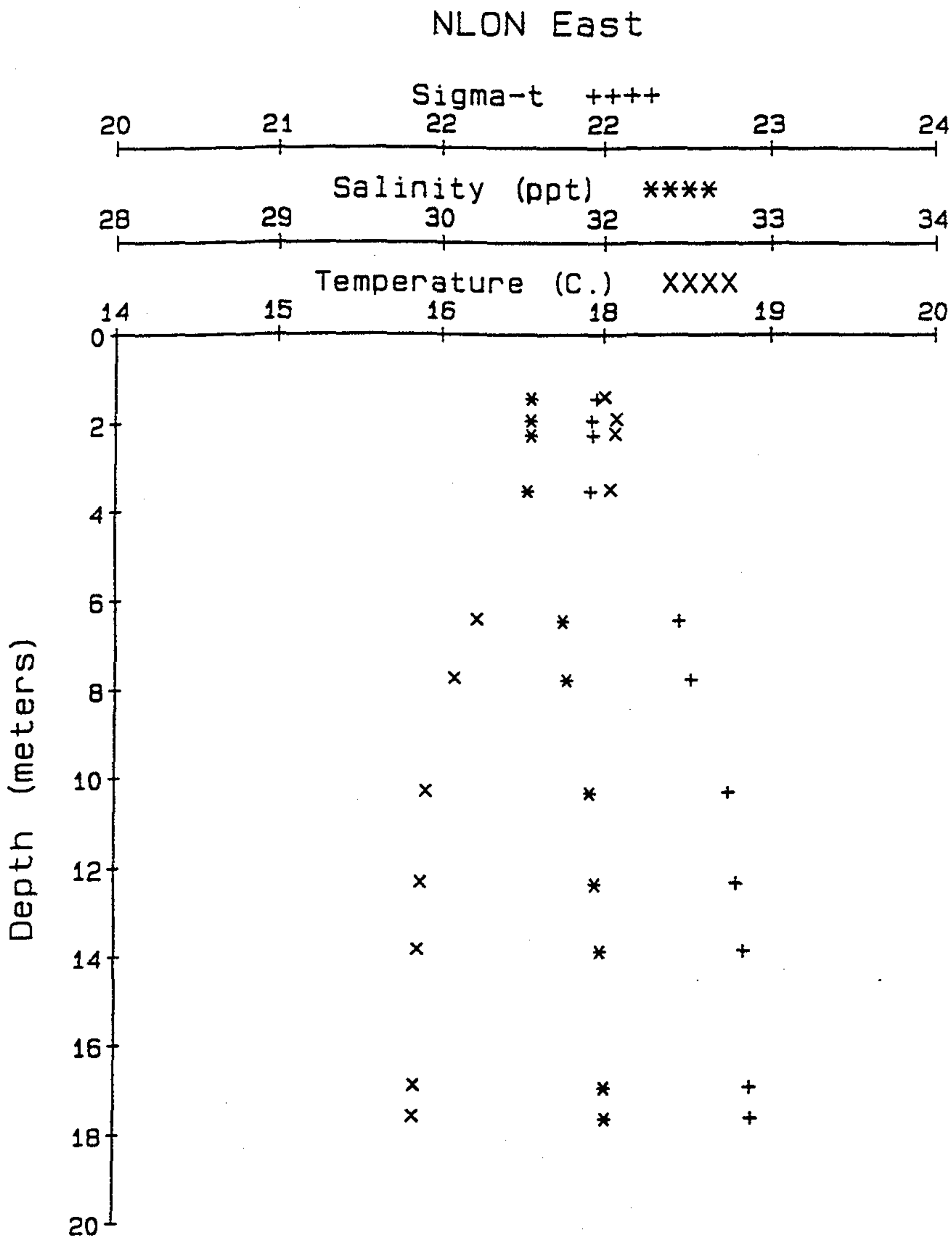
Salinity (ppt) ****
28 29 30 32 33 34
Temperature (C.) XXXX
14 15 16 18 19 20
Depth (meters)
0 2 4 6 8 10 12 14 16 18 20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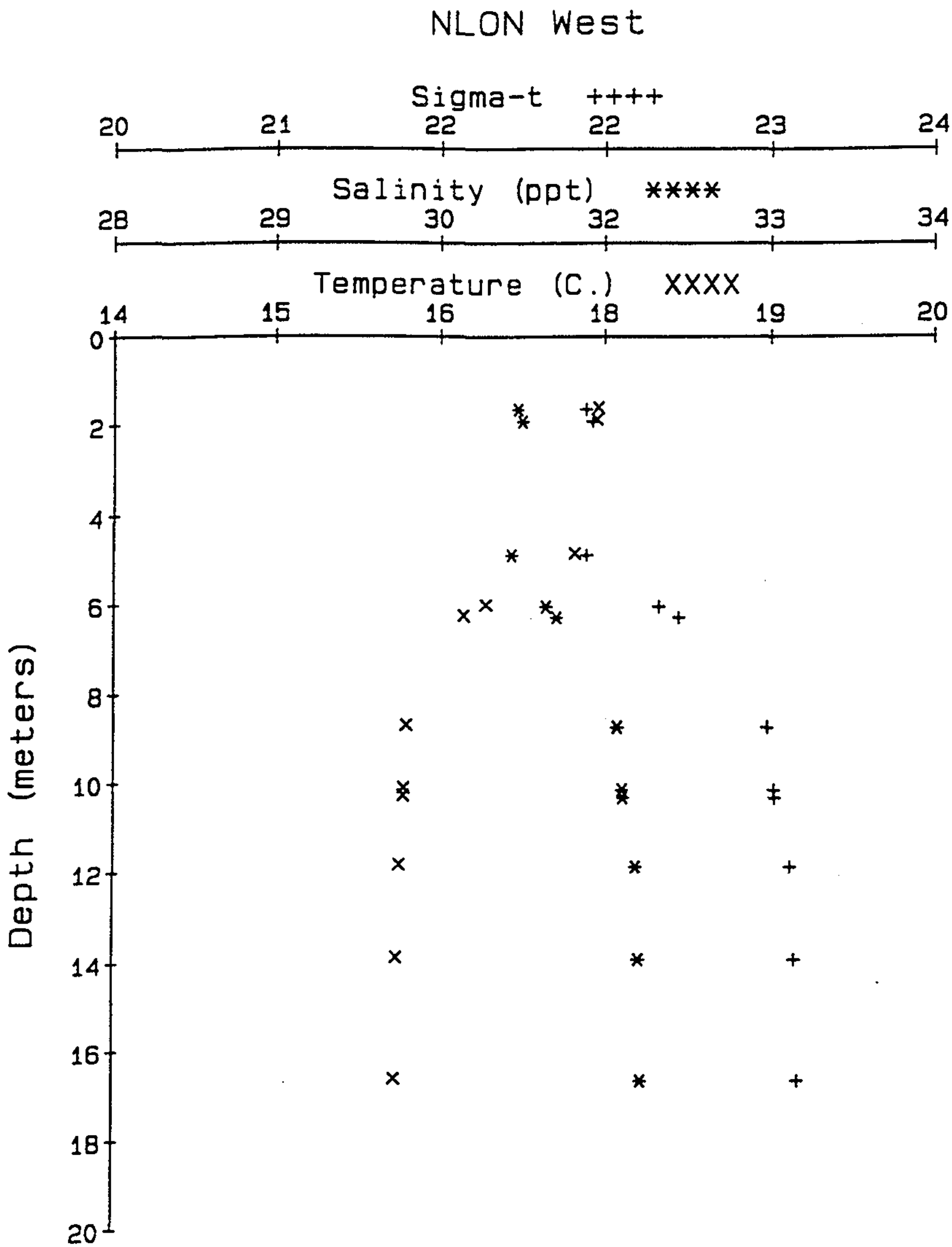
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Temperature (C.) XXXX
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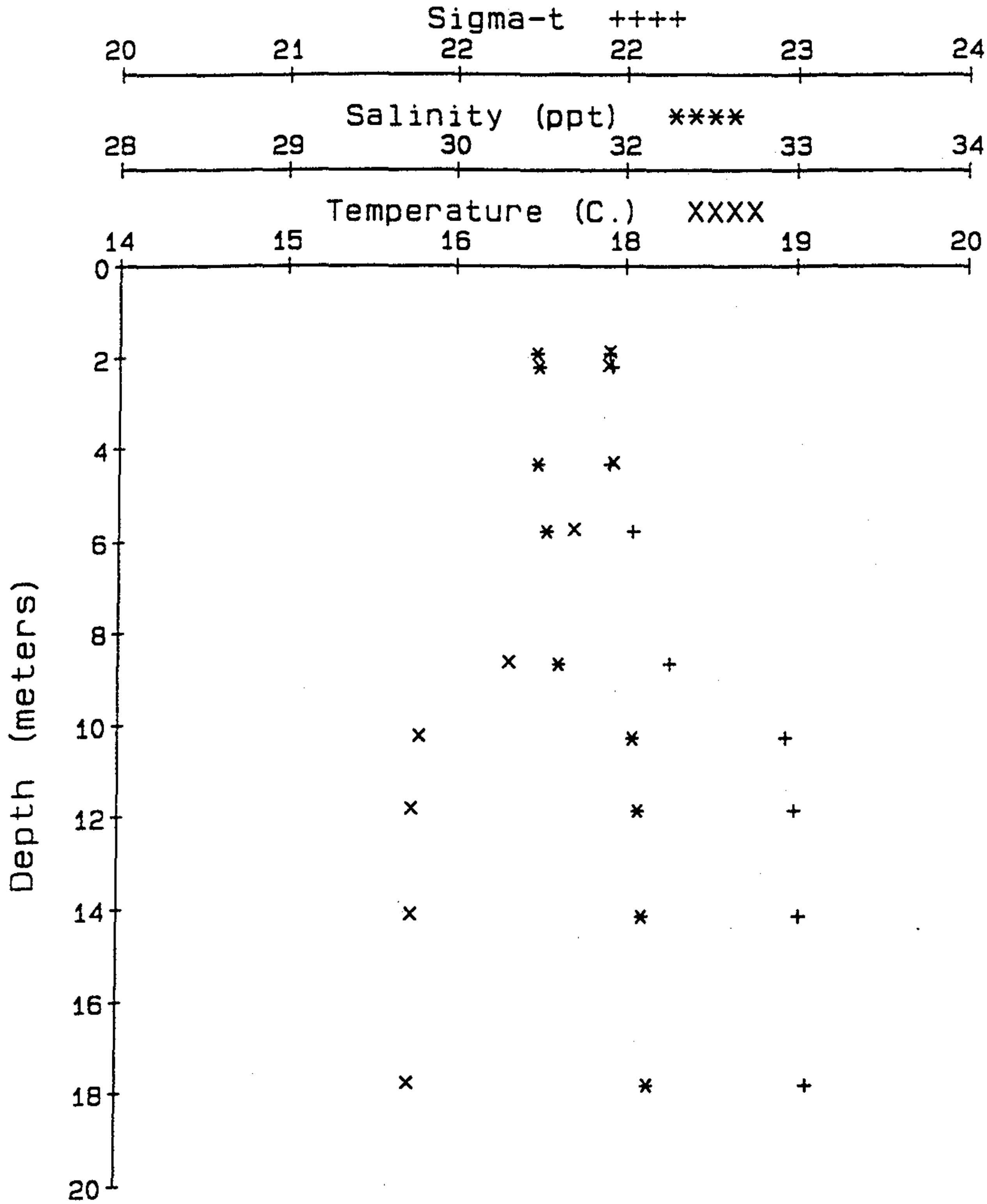
NLON South



Sigma-t ++++
20 21 22 22 23 24
Salinity (ppt) ****
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Temperature (C.) XXXX
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Depth (meters)
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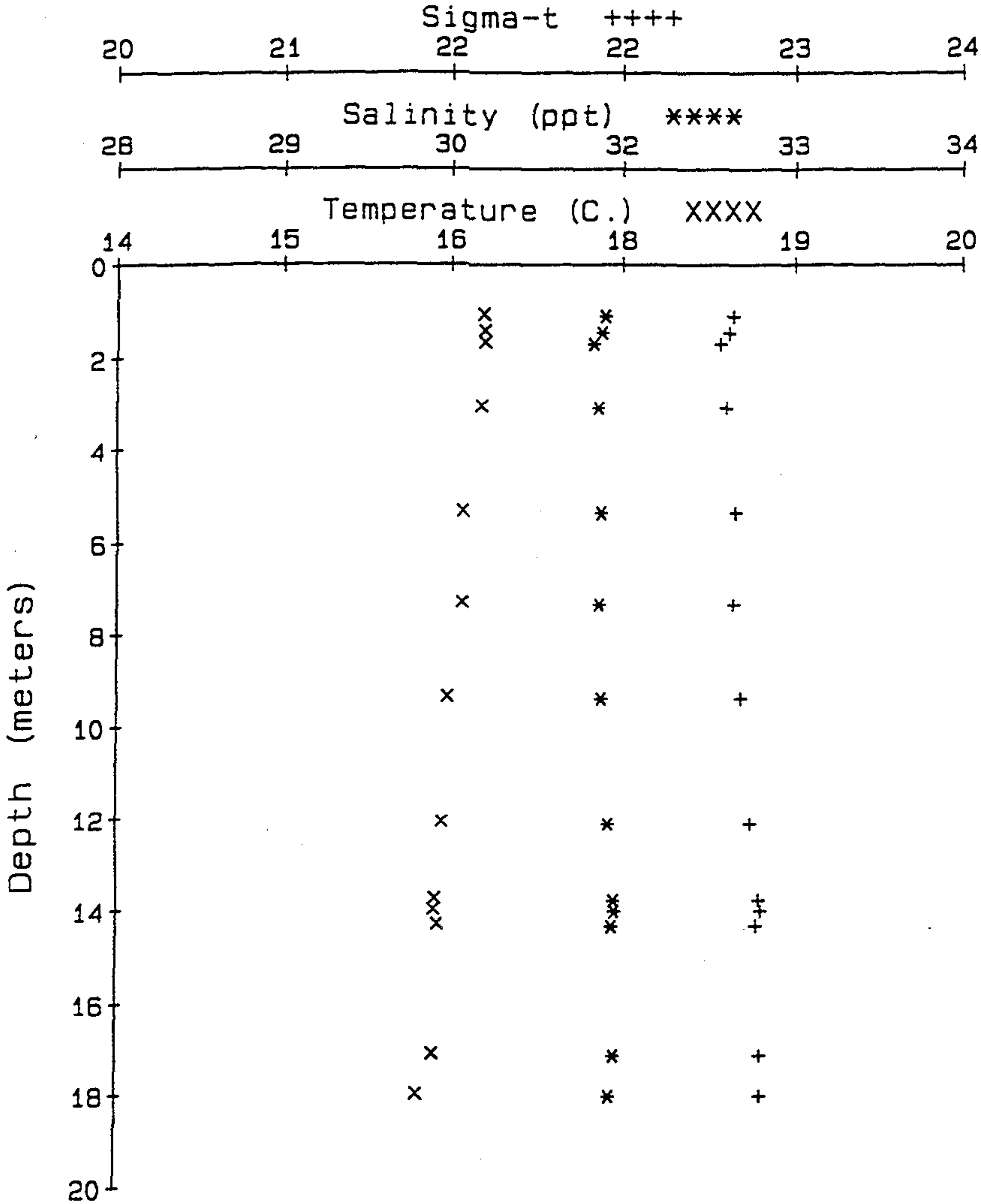
NLON-REF Center



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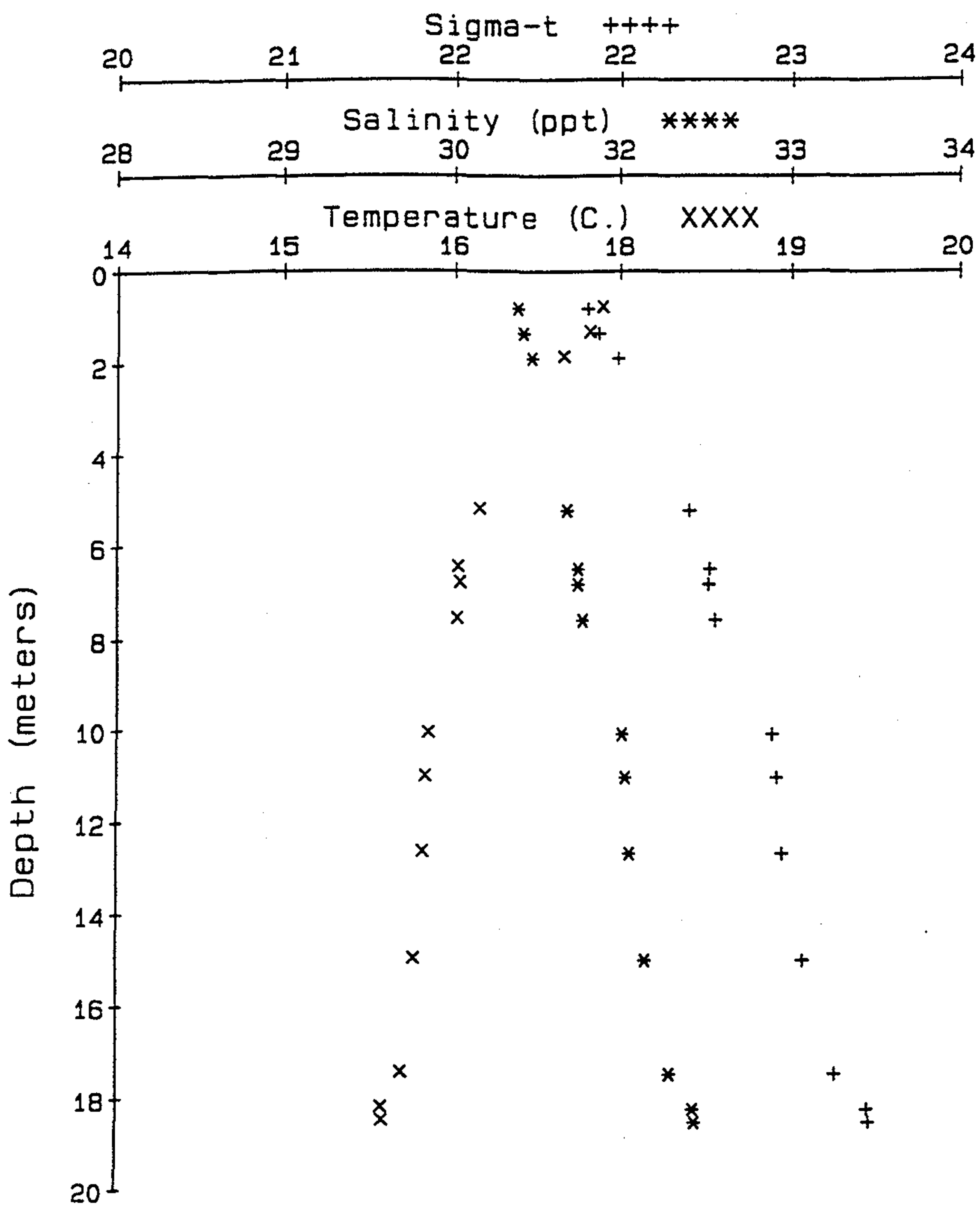
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Temperature (C.) XXXX
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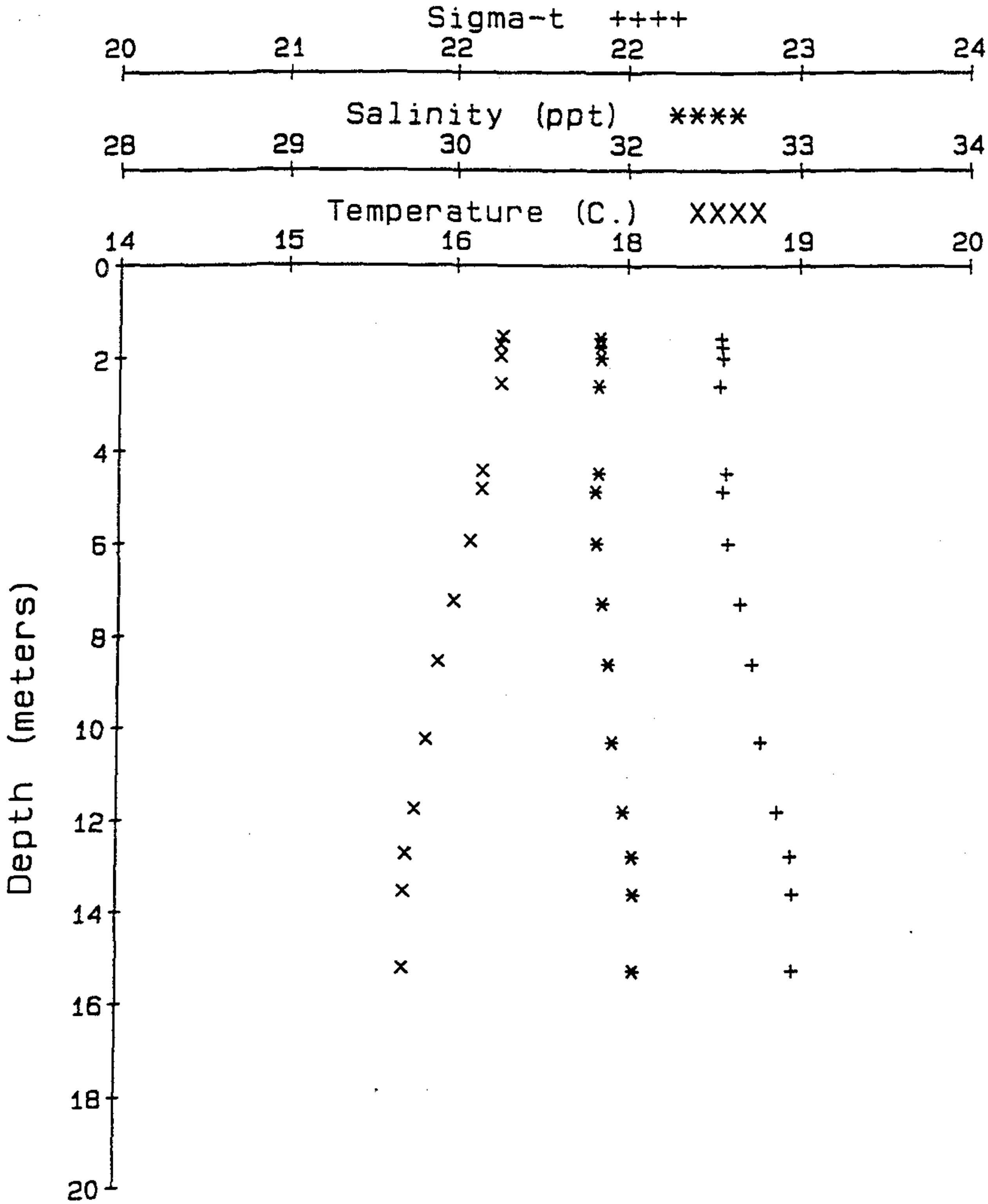
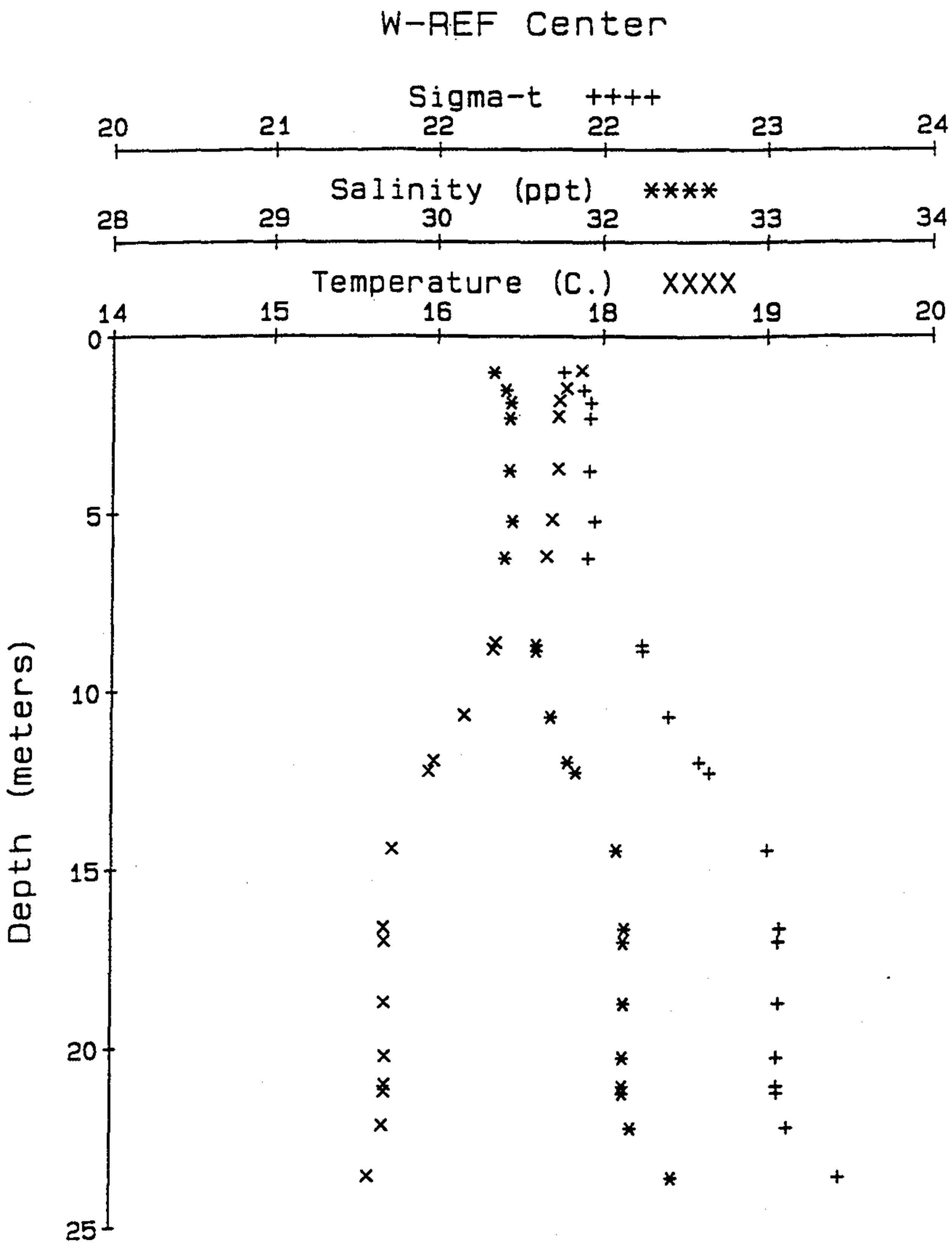
NE-REF Center




W-REF Center
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33
34
Temperature (C.) XXXX
14
15
16
18
19
20
0
5
10
15
20
25
Depth (meters)