1985 Monitoring Surveys
Western Long Island Sound
Disposal Site

Contribution #55
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Disposal Area Monitoring System DAMOS

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US Army Corps
of Engineers
New England Division

MONITORING SURVEYS AT THE WESTERN LONG ISLAND SOUND DISPOSAL SITE AUGUST AND OCTOBER 1985

Contribution #55

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1.0 INTRODUCTION

1. The Western Long Island Sound (WLIS) disposal site is located 2.5 nautical miles north of Lloyd Point between two previously used disposal sites designated as the Stamford and Eatons Neck dumping grounds. Currents in the area are known to flow generally in an east-west direction with maximum tidal velocities on the order of 25 cm/sec. The wave climate at the site is controlled primarily by the fetch distance, which is only significant in an easterly direction. SAIC's baseline sampling of the WLIS disposal site, conducted in January 1982, found that the depth in the center of the site was approximately 32 meters and that the sediments consisted primarily of fine silts and clays. At that time, the smooth topography of the site contrasted with the rougher topography of the surrounding area which was the result of previous disposal operations.

2. Disposal operations have taken place in the WLIS disposal site since 1982. In August 1985, a survey was conducted at the WLIS site to determine the effectiveness of management controls placed on the disposal of dredged material to minimize dispersal and environmental impacts. Precision bathymetric analysis was used to document the accumulation of material at the WLIS site, while REMOTS technology, grab samples, and direct underwater observations were used to characterize the sediments and biological community. Sediment samples were sent to NED for standard chemical and physical analyses.

3. An additional bathymetric survey was conducted in October 1985 to determine the effect of the passage of Hurricane Gloria on the disposal mounds and surrounding bottom. Precision bathymetric data was collected and compared with the August survey to detect large-scale changes in the volume and distribution of dredged material. Sediment samples were collected for chemical analysis to detect any transport of contaminated material. A REMOTS survey was also performed to document changes in benthic conditions and locate appropriate stations for possible future BRAT studies. BRAT sampling techniques include sediment grabs and fish trawls. The benthic organisms in the sediment are classified by size and compared with the same size classes of prey organisms found in the stomachs of demersal fish caught in the area. Analysis of this data determines the area's potential as a fisheries resource.

2.0 BATHYMETRY

4. A bathymetric survey was conducted at the WLIS disposal site on 23 August 1985 utilizing the SAIC Integrated Navigation and Data Acquisition System (INDAS) to provide precise positioning control. Figure 2-1 presents the survey grid performed at WLIS. This survey contains both WLIS "A" and "B" disposal points, as well as the most recent disposal location designated as "C". The active disposal point was moved to create

the "C" mound and to keep the "A" mound at its present depth. Presently, the disposal point is between mounds "A" and "C" so that future disposal operations will produce a single broad mound at a depth equal to mounds "A" and "C". Figure 2-2 presents the contoured bathymetric chart for the WLIS survey area in August 1985. The dominant feature that has appeared since the March 1984 survey (Figure 2-3) is the disposal mound just east of the buoy location, or mound "C". Mound "B", seen to the west of mound "A", was the result of the disposal of approximately 73,800 m^3 of material from Milford Harbor during April-June 1984.

5. Detailed examination of the depth matrix indicates the minimum depth at mound "C" to be approximately 28.6 meters. This new disposal mound is the result of disposal operations occurring from 10 to 75 meters east of the disposal buoy, according to available scow logs. The minimum depth of mound "A" has remained at approximately 29.2 meters since June 1984. Mound "B" has a minimum depth of approximately 32.4 meters.

6. Another bathymetric survey was performed on 30 October 1985 over the same grid (Figure 2-1) used during the August survey to detect significant changes in the topography of the disposal site after passage of Hurricane Gloria. Figure 2-4 presents the contoured bathymetric chart for the WLIS survey area in October 1985. Comparison of the August and October surveys reveals the lack of any large scale changes in the bottom topography at WLIS. Examination of the depth matrix for the October survey indicates minimum depths of approximately 28.6, 29.2 and 32.4 meters at disposal mounds "C", "A" and "B", respectively. These depth values are identical to the minimum depths obtained prior to the storm in the August 1985 survey.

7. Volume difference calculations were performed on a reduced grid size that encompassed only the disposal mounds and the immediate surrounding area. These calculations compare the average depth of each 25 m x 12.5 m grid cell for the August and October bathymetric surveys and sum the difference in depths over the entire survey area. The standard error for this accumulative volume change is calculated using the error of an individual depth measurement and a sample size of the number of grid cells that compose the survey area. Comparison of the October survey to the August survey resulted in a volume change of approximately 600 m^3 with a standard error of $\pm 4410\ m^3$. Calculation of the 95% confidence limits around this volume change indicates that the actual volume change falls anywhere in the range of -8044 to +9244 m^3. Therefore, one cannot conclude that a significant volume change has occurred.

3.0 REMOTS ANALYSIS

8. On 23 August 1985, a REMOTS survey was conducted at the WLIS disposal site. The purpose of this survey was to evaluate the dispersion of dredged material at WLIS and to determine the

distribution of benthic habitats for possible future BRAT studies. The August sampling grid consisted of a 36 station orthogonal grid (6 X 6) with stations equally spaced 200 meters apart. This grid encompassed that portion of the WLIS disposal site occupied by disposal mounds "A", "B" and"C". The locations of the center of these mounds and the August REMOTS stations are indicated on Figure 3-1. A single REMOTS replicate image was obtained at each station. Twenty REMOTS images were also obtained at the WLIS-REFERENCE site (see Figure 2-1).

9. On 27 September, approximately one month after the August Survey, Hurricane Gloria moved through Long Island Sound. Maximum wind speeds associated with this event reached 90-100 mph in Long Island Sound for 2-3 hours from the south/southeast. During the course of Gloria up the East Coast, the pressures were the lowest ever recorded. Although Gloria had the potential to approach the magnitude of a 100-year storm, the rapid dissipation of energy after reaching Connecticut had caused the estimated expected frequency of a storm like Gloria to fall between 10 and 50 years. This high-energy event provided a unique opportunity to assess the containment quality of the WLIS site and the stability of the dredged material mounds. A WLIS post-storm survey was conducted on 31 October 1985, one month after the storm. The post-storm REMOTS sampling grid focused on disposal mounds "A", "B", and "C". Stations were located at the center, 50 meters north, south, east, and west of each of the three mounds. A circle of ten additional stations surrounded all three mounds approximately 400 meters away in all directions (see Figure 3-12). In the REMOTS analysis of the post-storm images, special emphasis was placed on the detection of erosional and depositional features at both on-mound and off-mound (fringe) stations.

10. In addition, ten stations extending from the Norwalk harbor entrance to the WLIS disposal site were occupied (see Figure 3-21) to evaluate the distribution of sediment resuspension as a function of depth and distance from shore. A single REMOTS replicate was obtained at all post-storm stations.

11. Methods of REMOTS image interpretation are described in earlier DAMOS reports and are not repeated here.

3.1 August Survey

12. The distribution of dredged materials in the area surveyed is shown in Figure 3-1. It must be stressed that the optical detection of dredged material in the WLIS disposal site can be equivocal. Typically (e.g. at Central LIS disposal sites) dredged material is readily discerned in REMOTS images because of its extreme low reflectance (blackness) relative to ambient reduced sediments. When dredged material layers are thicker than the REMOTS prism penetration depth (15-20 cm), these extremely "black" sediments extend to the bottom of the film frame and contrast sharply with high reflectance (oxidized) surface

sediments. When dredged material layers are less than prism penetration depth, the relict or pre-disposal sediment surface (relatively high reflectance) can also be seen beneath the black dredged material layer (Figure 3-2). In the WLIS survey area, "ambient" sediments are highly reduced (extremely low reflectance) and generally exhibit shallow RPD depths; this is due to high levels of organic loading, restricted water exchange and the severe sediment oxygen demand characteristic of the western Long Island Sound region. As a result, disposed dredged materials do not markedly contrast with ambient, reduced subsurface sediments. Also, the signature of buried pre-disposal oxidized layers may not be distinct or persistent.

13. The data given in Figure 3-1 should be examined in light of this caveat. Dredged material is concentrated across the central and southeastern portions of the survey area. This is expected given the locations of the recently used and active disposal points. Some dredged material may also be present along the northern edge and in the southwestern portion of the sampling grid. Dredged material may extend eastward beyond the area surveyed. However, this material would still be contained within the boundaries of the WLIS disposal site (see Figure 2-1). It is important to note that dredged material is evident as a distinct depositional layer in 50% (10 of 20) of the REMOTS replicates from the WLIS reference station (Figure 3-3). This station is located approximately 2000 meters east of the survey area near an historically-used disposal site (Eatons Neck). The observed dredged material apparently represents sediments derived from previous disposal operations in the region.

14. A benthic "process" map of the survey area is shown in Figure 3-4. A process map presents features observed in REMOTS images which are indicative of bottom disturbance. The scale of these disturbance features is on the order of the REMOTS window height (up to 20 cm). The WLIS survey area consists predominantly of silt-clay sediments (>4 phi). Additionally, very fine to fine sand layers (ranging from 4 to 2 phi) are present at a number of stations. Five of the six stations along the southern transect reveal a coarse-grained surface layer on the order of 1 cm thick (Figure 3-5). These stations also exhibit shell lag deposits and mud clasts, and REMOTS prism penetration was shallow relative to the rest of the site. These features indicate that this portion of the grid represents a relatively high kinetic region. Based on the bathymetric survey discussed in Section 2.0, it is apparent that this southernmost row of stations lies outside the WLIS trough in an area where the seafloor begins to shoal. Near-surface sand layers are also apparent at four stations in the northeast quadrant of the grid (Figure 3-6). These stations are located close to disposal mounds "A", "B", and "C". The sand layers may represent lag deposits produced by the winnowing action of bottom currents in the immediate vicinity of the disposal mounds. Alternately, these sands may represent dredged material.

15. The frequency distributions of surface boundary roughness values for the sample grid and WLIS-REF are shown in Figure 3-7. Boundary roughness is the vertical range of small-scale topographic relief observed in the REMOTS images. The major mode for the area surveyed is at 0.4 cm, suggesting that the region is generally a low-kinetic one. However, the presence of mud clasts at five stations (excluding the southernmost transect) indicates that some localized bottom disturbance has occurred (Figures 3-4 and 3-6). This disturbance is likely both physically-induced disposal operations and biogenic macrofaunal foraging. Near-surface patches of highly reduced sediment are evident in 36% of the WLIS REMOTS images (Figure 3-8). Reduced sediment patches have also been observed at the Central Long Island Sound Disposal Site (CLIS) surveyed in the summer of 1985. This phenomena may be related to the large-scale sediment reworking activity of deep-dwelling Stage III infauna and/or large, mobile predatory epifauna, e.g. decapods and stomatopods. The ecological significance of this phenomena and its impact on dredged material disposal mounds is discussed in detail in the CLIS August and post-storm report.

16. The frequency distribution of the Redox Potential Discontinuity (RPD) depths for the survey area and WLIS-REF is shown in Figure 3-9, and the spatial distribution of RPD depths is given in Figure 3-10. The RPD value is a measure of the apparent depth of aerobic sediment, indicative of bioturbation activity. In general, the WLIS disposal site has historically displayed relatively shallow RPD values. The average RPD depth for the entire site is 2.95 cm; this is not significantly different from the average RPD depth of 3.24 cm at WLIS-REF (Mann-Whitney U-test, $p = .4107$). In general, this region of Long Island Sound is "stressed" due to high natural and anthropogenic inputs of organic-rich material coupled with restricted water movement. These conditions result in high sediment BOD and COD. Organic-loading is further indicated by the high contrast RPD's prevalent throughout the region, i.e. sediments at depth are apparently highly reduced (manifested as very low reflectance). Several stations also exhibit rebounded RPD's (Figures 3-10 and 3-11); this is likely related to the seasonal temperature increase and the associated increase in sediment oxygen demand. Figure 3-10 shows that there is no obvious spatial pattern in the distribution of RPD depths across the survey area.

17. A map of infaunal successional stages is shown in Figure 3-12. Based on the theory that organism-sediment interactions follows a predictable sequence after a major seafloor perturbation, the successional stage represents the functional group of infauna present in REMOTS images. Sixty-seven percent of the images show Stage I seres, reflecting the disturbed condition of the region. Of 11 stations exhibiting Stage III seres, eight are located in the western half of the survey grid. This may be related to the fact that the dredged material disposal mounds are located in the eastern portion of

the survey area. Fifty percent of the WLIS-REF replicate images exhibit Stage I seres. There is no difference in the successional status of the survey area and the WLIS-REF station (Chi-Square test; p = .3807); this indicates that the reference station also represents a disturbed environment.

18. The frequency distributions of Organism-Sediment Index values at WLIS and WLIS-REF are shown in Figure 3-13. Both regions display a wide range of values (+3 to +11) indicative of a patchy benthic environment. The mapped distribution of OSI values shown in Figure 3-14 further illustrates this spatial heterogeneity. The western half of the survey area displays generally higher OSI values, reflecting the distribution of Stage III infauna. In particular, a small region of +10's and +11's is apparent in the central, western portion of the survey area. Overall, the OSI values are low (i.e. less than +7); this is due to both the shallow RPD's and the low-order successional status. As discussed above, this is apparently related to the high organic loading characteristic of the WLIS region.

19. In relation to possible future BRAT studies in the WLIS disposal site, two sampling strata are indicated; a station in the region comprised of Stage I assemblages and a station in the relatively "undisturbed" Stage III-I regions (e.g. the hatched areas in Figure 3-12). This sampling would ensure that the resource potential of both types of infaunal seres present in the area are quantified.

3.2 Post Storm Survey

20. Figure 3-15 shows the post-storm distribution of dredged material as well as features indicative of bottom disturbance. Although the sampling grid is reduced relative to the August survey, there is no evidence of dredged material beyond the immediate vicinity of the disposal mounds. This pattern supports the findings on the post-storm bathymetric survey which indicate that no large-scale redistribution of dredged material has occurred. Conversely, evidence of small-scale disturbance (i.e. less than the REMOTS prism penetration depth of 15-20 cm), such as sand and shell lag deposits, mud clasts, and chaotic sedimentary fabrics, can be seen in several images. Such features were not as distinct or ubiquitous in the August survey; this apparently illustrates the effects of Hurricane Gloria on the surface sediments. These features are most apparent near the center of disposal mounds "C" (stations CTR, 50N, 50E) and "A" (station CTR). Two fringe stations (C-400N and C-400S) also exhibit evidence of sediment resuspension. The pattern of disturbance is possibly related to the size of the respective disposal mounds (see Section 2.0), with the largest and highest mound "C" showing the greatest evidence of surface disturbance. Although the features mapped in Figure 3-15 indicate disturbance of the top 0-15 cm of the bottom, the amount of material resuspended or eroded as a result

of the storm is not readily discernible due to the lack of an identifiable pre-storm datum.

21. The frequency distribution of surface boundary roughness values for all post-storm stations is shown in Figure 3-16. The major modal value is 0.8 cm; this compares to a major mode of 0.4 cm in August and apparently reflects enhanced surface roughness due to the storm.

22. The frequency distribution of RPD depths is shown in Figure 3-16 and the spatial distribution of these values is presented in Figure 3-17. RPD depths on the seafloor surrounding the disposal mounds are lower than those observed in August (see Figure 3-10). Moreover, four stations exhibit no apparent RPD, indicating that the sediment column (and perhaps the near-bottom waters) are anoxic or hypoxic. All stations exhibited measurable redox layers in August. Three of these low oxygen stations are near the center of a disposal mound. This reduction in RPD depths may be related to the storm-induced erosion of surface oxidized sediment layers. Based on the August RPD depths, the removal of the top 2-3 cm of sediment would place highly reduced subsurface sediments at the interface (Figure 3-18). The two disposal mounds ("A" and "C") which show the most evidence of physical disturbance also exhibit shallow RPD's. Shallow RPD's at several fringe stations (e.g. A-400N, C-400N, C-400S, C-400S/200E) also suggest some localized small-scale erosion (1-3 cm) in these areas.

23. The distribution of infaunal successional stages is shown in Figure 3-19. Interestingly, Stage III infauna are apparent on the disposal mounds, but not on the surrounding seafloor. This pattern is not readily explained. However, as in August, the area surveyed, taken as a whole, consists predominately of Stage I seres (77%).

24. The frequency distribution of the post-storm Organism-Sediment Index values is given in Figure 3-16, and the mapped distribution of these values is given in Figure 3-20. The indices range widely from -3 to +9 indicating a mosaic of benthic conditions. However, throughout most of the area surveyed, the OSI's are low (most values are less than +6). This reflects the shallow RPD values, the low bottom water dissolved oxygen levels, and the lack of high-order successional infauna. Overall, the benthic community inhabiting the survey area region appears to have been markedly stressed by the effects of Hurricane Gloria. Future REMOTS surveys should be able to document the persistence of the storm's impact on this region.

3.3 WLIS Transect

25. The REMOTS WLIS transect extended from the entrance of Norwalk harbor to the WLIS disposal site (Figure 3-21). The purpose of this transect was to determine the distribution of storm-induced bottom disturbance features as a function of depth

and distance from shore. Only two stations along the transect (T-8 and T-3) show distinct evidence of bottom disturbance (Figure 3-22). All remaining images show an "undisturbed" bottom with an intact RPD layer and dense Stage I assemblages (Figure 3-23). Given that widespread disturbance was evident on the deeper WLIS disposal mounds, the general lack of disturbance along the WLIS transect (ranging in depth from 10 to 30 meters) is notable. The sediment stabilizing effects of the dense mats of Stage I organisms most likely influenced the pattern of bottom disturbance. Stage I assemblages within the WLIS survey area were comprised of many fewer animals per cm^2.

4.0 SEDIMENT CHARACTERISTICS

26. During the August 1985 survey at the WLIS disposal site, replicate sediment grabs were collected with a Smith-McIntyre grab sampler (0.1 m^2) at the center of mounds "A", "B", "C" and the reference site (see Figure 2-1) for physical and chemical analysis by NED. The sediment at all four sites was described as dark grey organic sandy silty clay, with shell hash also present at the reference site. The pH varied from 6.9 to 7.2 and the specific gravity from 2.62 to 2.68. Samples at the center of mound "C" contained as much as 87% silt/clay, while sediment from mounds "A" and "B" contained 58% and 60%, respectively. The reference site sediment contained 78% silt/clay.

27. Table 4-1 presents the results of the chemical analysis of the sediment at the four sites. No major trends are evident in the data, although the sediment at the reference site tends to have reduced concentrations of Pb, Cr, and Cu. Mound "C", the site of recent disposal operations, contains sediment with higher concentrations of Fe and Cu and lower concentrations of Zn.

28. Comparisons of these results with data collected in June 1984 at mounds "A" and "B" and the reference station revealed that the concentrations of most metals are similar to or less than the 1984 results. Hg concentrations are higher for the August 1986 sediments, but are similar to those found at the reference site. The data does not indicate any major change in the level of contamination of the dredged material.

29. Sediment samples were also collected in October to assess whether there were differences in the surface sediments covering the mound as a result of sediment redistribution. The six stations sampled included those sampled in August 1986 and were located at the center and 50 meters south of mounds "A", "B" and "C". Table 4-1 includes the results from the chemical analysis of these samples.

30. The sediment at mound "A" was described as dark gray clayey sand with traces of shell fragments and approximately 40% fines. The sediment at mounds "B" and "C" was described as dark

gray sandy clay with shell fragments having approximately 62-88% fines. The specific gravity of all the samples ranged from 2.60 to 2.68. The sediments at mound "A" showed slight decreases in concentration of Fe, Cd, Cr, Cu and Ni when compared to concentrations in the sediment collected there in August. However, the sediment at mounds "B" and "C" showed no consistent trends as to changes in metal concentration. Due to the large variance in these data, many more sediment samples would be required to detect significant changes in sediment metal concentrations.

5.0 IN-SITU OBSERVATIONS

31. Direct underwater observations were made at Mounds "A" and "B" at WLIS by the SAIC team of diver/scientists during the August 1985 field investigation. Observations were made of the sediment surface conditions, presence and abundance of macrofauna, and faunal-substrate interactions. Photo-documentation was accomplished with a hand-held 35 mm camera, 28 mm lens with supplementary diopter (144 mm x 216 mm area of coverage), and electronic flash. Diver-operated epibenthic net samples (0.50 m side x 0.20 m height net; 1 mm mesh; 15 m tow) were taken at discrete points for enumeration of abundant smaller species associated with the substrate surface.

32. Recolonization by megafauna of both sites at WLIS seems to be proceeding in a manner similar to other Long Island Sound disposal sites. Although the estimate of the rate of recolonization is qualitative based on visual observations, it seems that the condition of the benthic community has not significantly affected the larger species. Motile megafauna, typical of the deep western Long Island Sound assemblage, are present and abundant on the site. Lobster, _Homarus americanus_, are present at both mounds "A" and "B". Juvenile rock crabs, _Cancer irroratus_, utilized available space under bivalve shell debris to excavate shelters. Due to the numerical dominance of decapod crustaceans in the area and their typical interactive behaviors with the substrate surface, they appear to be the major bioturbators associated with these sites.

33. Pelagic species present at the site (squid, _Loligo pealei_ and butterfish, _Peprilus triacanthus_) are known predators of a variety of benthic crustaceans. These species provide trophic linkages from demersal to pelagic communities.

34. Figures 5-1 to 5-10 depict conditions and faunal-substrate interactions typical of the WLIS site. The shell debris material deposited at the site provides cover for the juvenile forms of a variety of species. By increasing substratum complexity, disposal activities appear to be providing refugia for juvenile epibenthic megafauna, thereby increasing the resource value of the site for these particular taxa.

5.1 Site "A"

35. The survey dive was conducted in an approximately 0.25 kt (east to west) current. Horizontal visibility was approximately one meter. A high density of suspended material over the bottom (nepheloid layer) was approximately 2 cm deep and moving with the current. The substrate surface consisted of fine silt material with 3 m wide patches of shell hash covering approximately 10% of the surface in the dive area. The bottom was flat with no deep vertical burrows. Crustacean activity was the apparent major source of surface bioturbation.

36. This site had a diverse megafaunal assemblage (Table 5-1) dominated by crustaceans. Juvenile rock crabs, Cancer irroratus, (2 to 3 cm, carapace width) were observed tracking over the bottom and burrowing under shell debris or in open sediments. Small hermit crabs, Pagurus longicarpus, were also very abundant. Mobile crabs created tracks in the sediment surface, and burrowed crabs sifted sediments through their mandibles; both activities destabilized surface sediments. Lobsters, Homarus americanus and cunner, Tautogolabrus adspersus, were attracted to debris on the site, because both species require cover and exhibit thigmotactic response to small-scale topographic features.

5.2 Site "B"

37. The survey dive was conducted in an approximately 0.1 kt (east to west) current. Horizontal visibility was approximately 0.75 meter. The substrate consisted of a 1 cm deep fine silt layer over gray-black clay material. The surface was flat and featureless. Tree branch debris was present. Animal tracks were ubiquitous over the surface.

38. As at the "A" site, crustaceans were the dominant megafaunal group (Table 5-1) and responsible for major surface bioturbation of sediments. No deep vertical burrows were observed at this site.

6.0 CONCLUSIONS

39. The August 1985 bathymetric survey revealed the presence of three disposal mounds in the WLIS disposal site. The newest mound ("C") is the result of disposal operations occurring since the June 1984 survey. The post Hurricane Gloria survey did not detect redistribution of the disposed dredged materials at the 15-20 cm level of resolution obtained with the precision bathymetric survey techniques used.

40. The August REMOTS data indicate that dredged material is concentrated across the central and southeastern portions of the survey area. In general, western Long Island Sound is a

"stressed" benthic environment. This is likely due to the high natural and anthropogenic inputs of organic-rich material and restricted water movement characteristic of this region of Long Island Sound. In general, higher-order successional infauna are found only in the western portion of the survey area (away from the most recent disposal operations). Evidence of widespread megafaunal bottom disturbance is apparent in many of the REMOTS images. In-situ diver observations confirm that abundant motile epifauna, e.g. decapods, are the major cause of bioturbation on the disposal mounds. By increasing substratum complexity, disposal activities appear to be providing refugia for juvenile epibenthos.

41. REMOTS imagery can detect small-scale seafloor disturbance features from 0-20 cm in extent (the height of the REMOTS window). The post Hurricane Gloria REMOTS survey shows widespread evidence of this small-scale physical disturbance, e.g. mud clasts, shell lag layers, enhanced boundary roughness. These features indicate that near-surface sediments in the survey area were recently resuspended or eroded. Disturbance features are most prevalent on the two larger mounds "A" and "C". Severe sediment oxygen demand is also apparent at the site; this is most likely due to erosion of surface aerobic sediment layers which exposes reduced sediments to the sediment-water interface. This hurricane-induced near-surface disturbance appears to have stressed the benthic community in the WLIS survey area.

42. In terms of disposal site management, the post-hurricane results indicate that despite evidence of small-scale (<20 cm) disturbance of the disposal mounds and the associated benthic community, no significant redistribution of dredged materials occurred in the WLIS survey area.

43. The pre- and post-storm distribution of dredged material indicates that the passage of Hurricane Gloria did not affect the stability of the disposal mounds or the containment properties of the WLIS disposal site. Because the level of contamination of the dredged material is the same or less than the surrounding sediment, the movement of contaminants outside of the immediate survey area was not detectable.

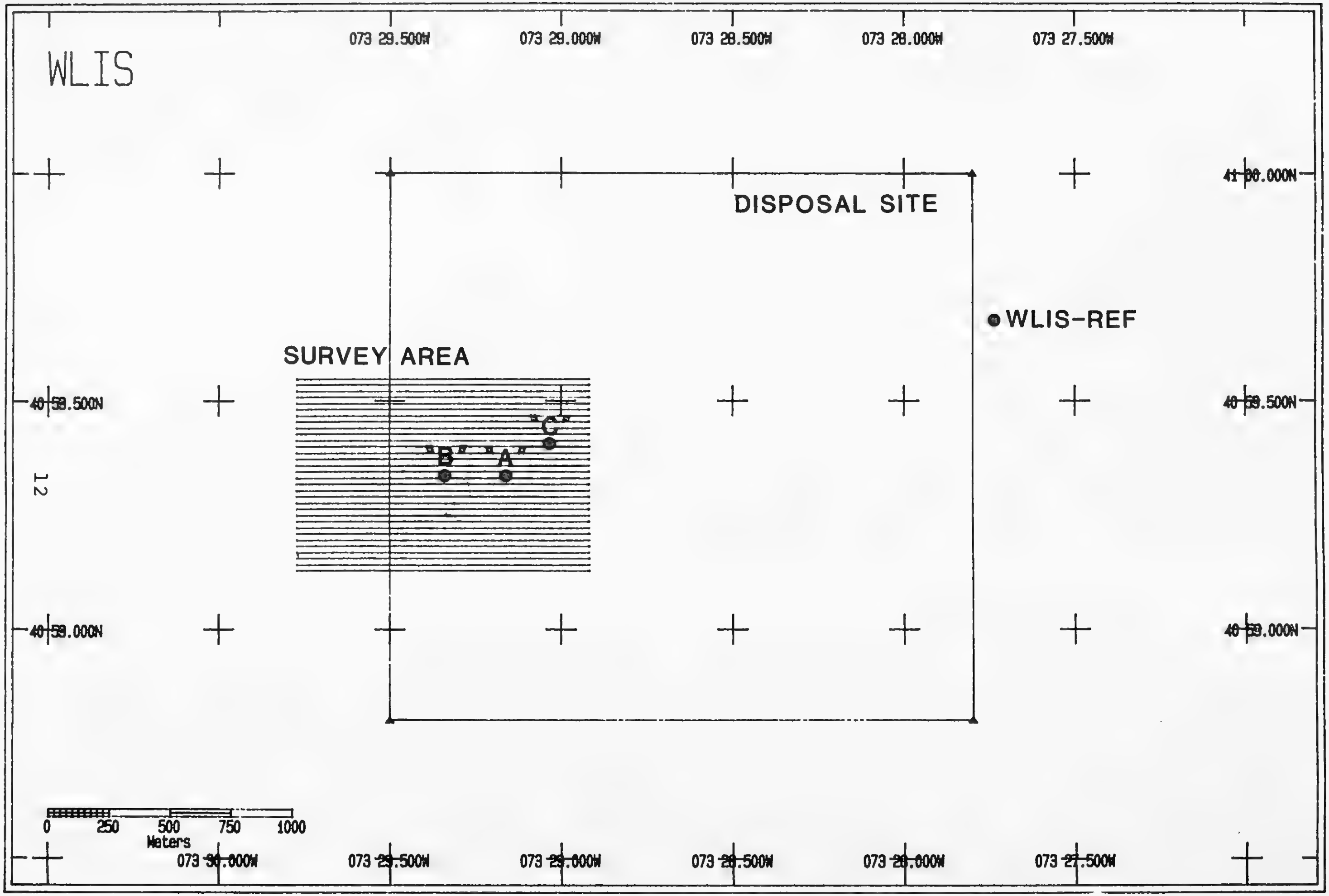


Figure 2-1. Sampling locations at WLIS Disposal Site, August and October 1985.

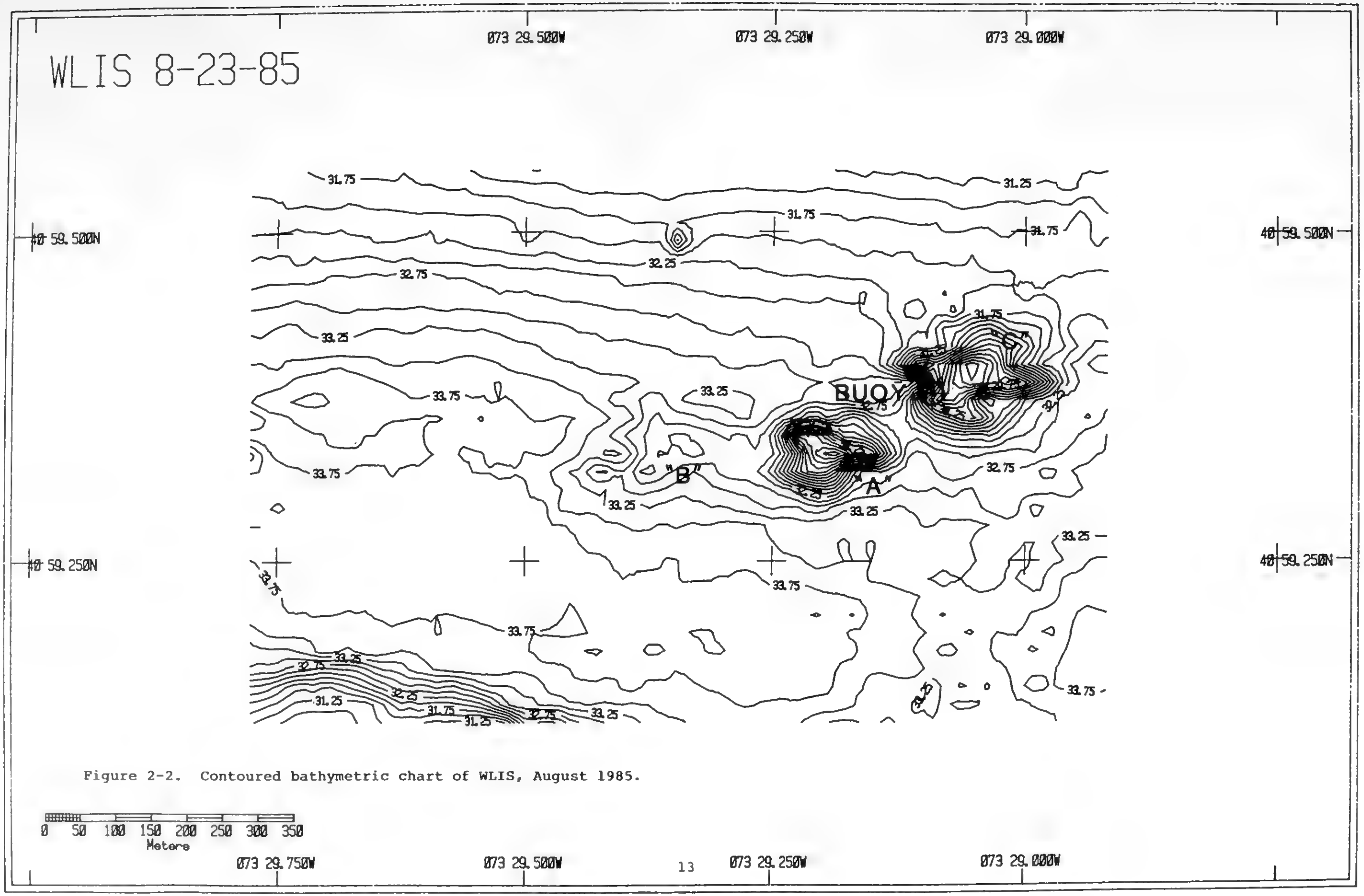


Figure 2-2. Contoured bathymetric chart of WLIS, August 1985.

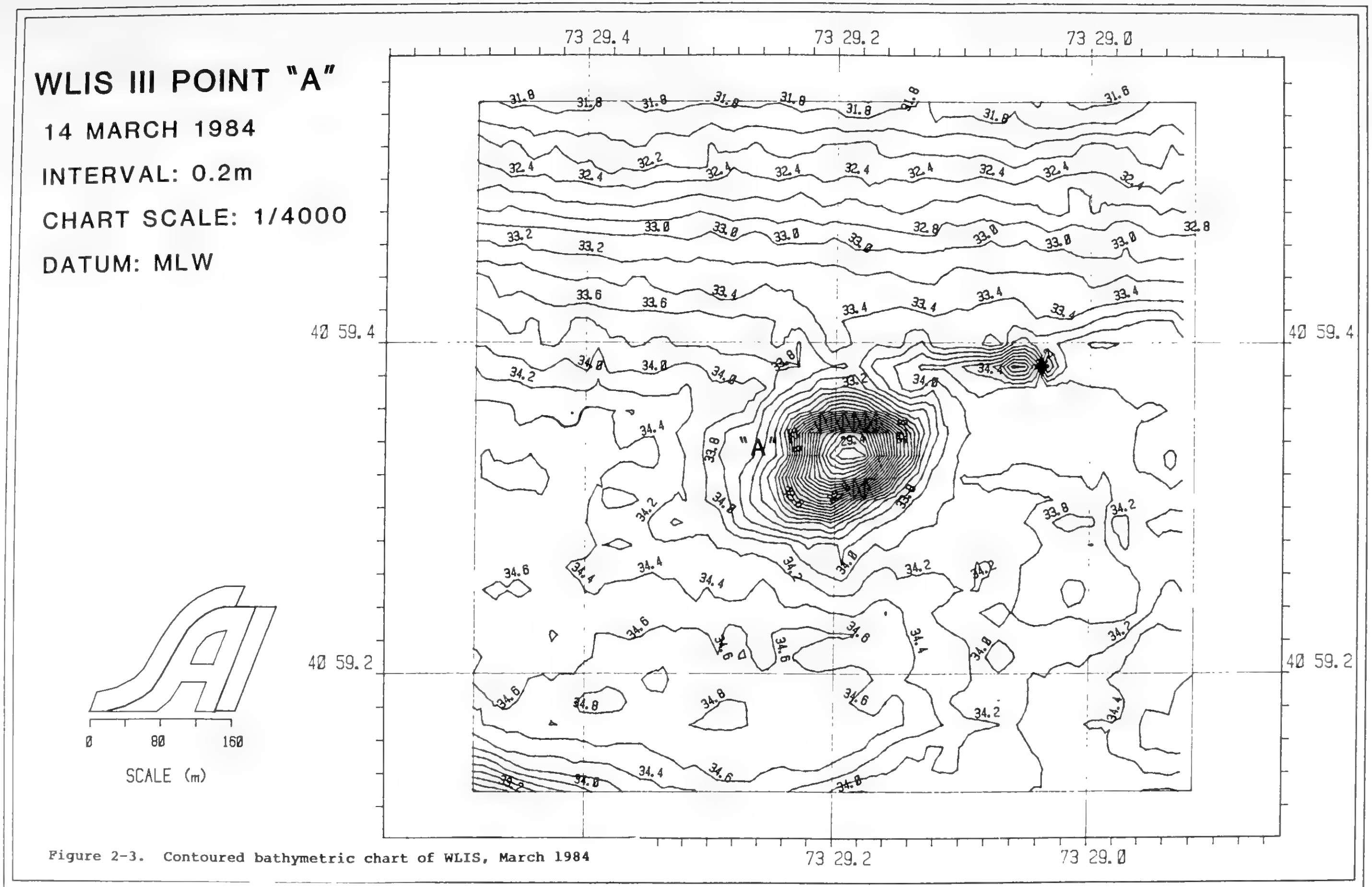


Figure 2-3. Contoured bathymetric chart of WLIS, March 1984

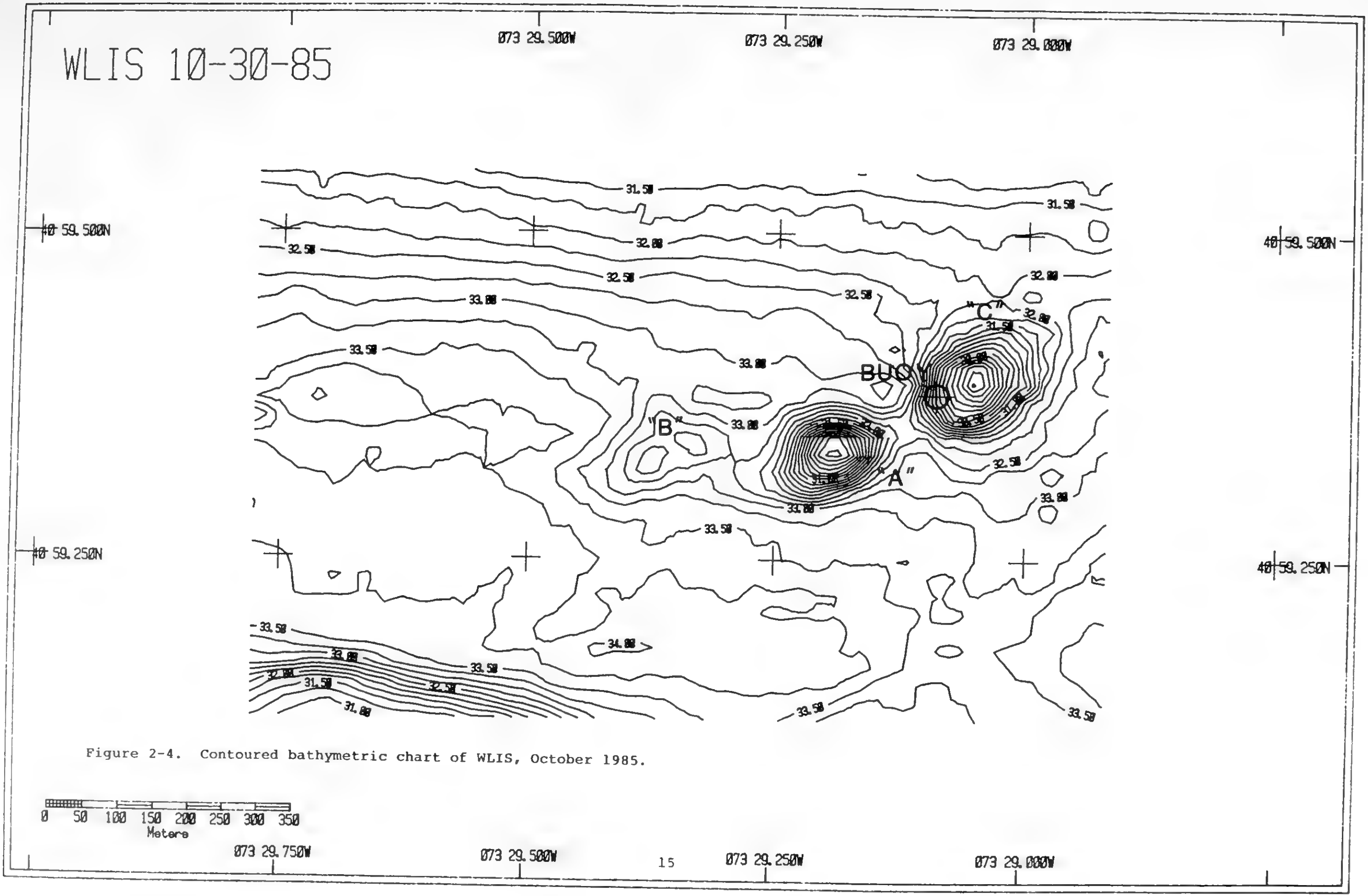


Figure 2-4. Contoured bathymetric chart of WLIS, October 1985.

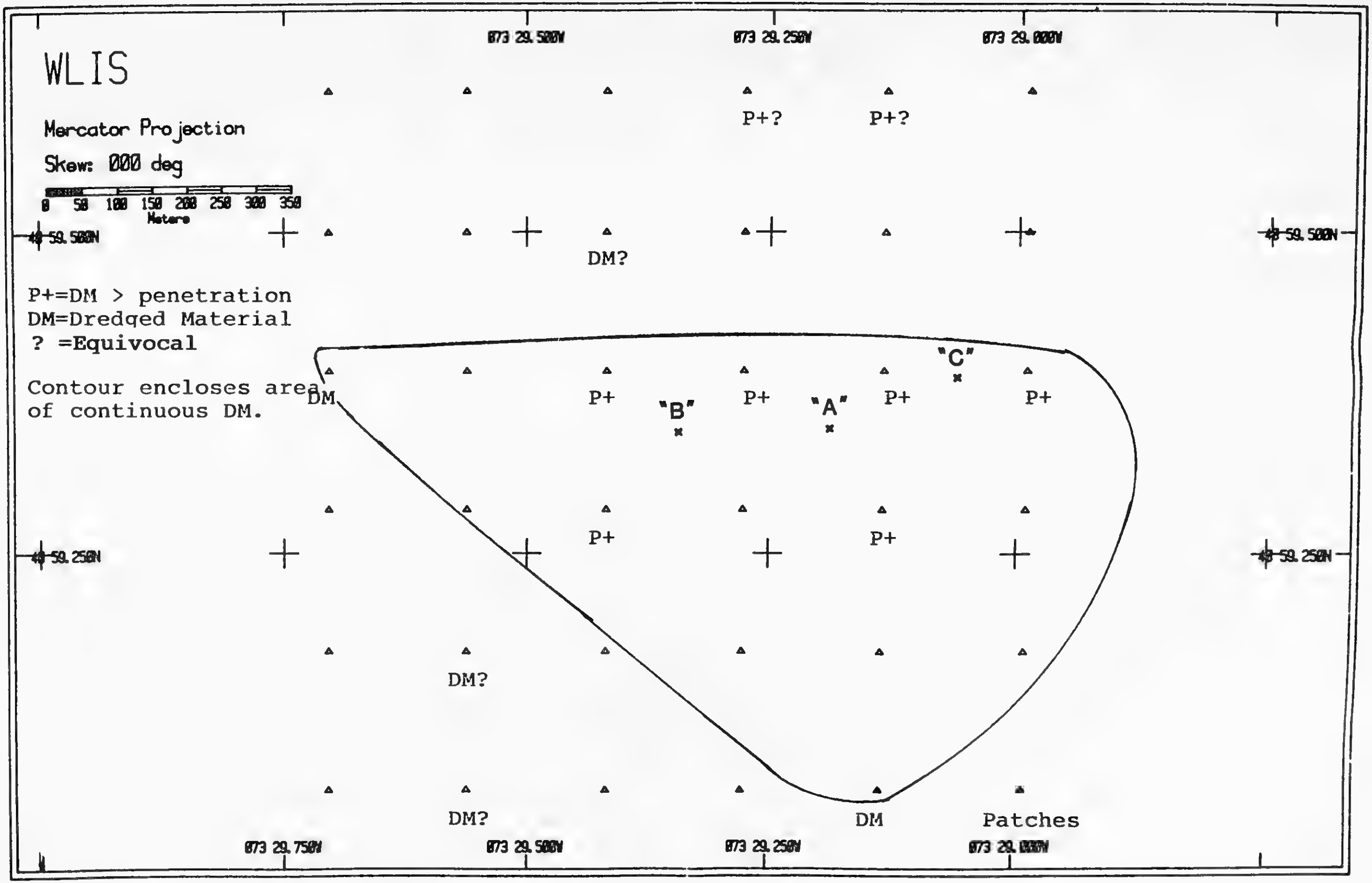


Figure 3-1. Distribution of dredged material at WLIS, August 198

Figure 3-2. REMOTS photo of dredged material at station 100N/500N.

Figure 3-3. REMOTS photo of dredged material at WLIS-Reference.

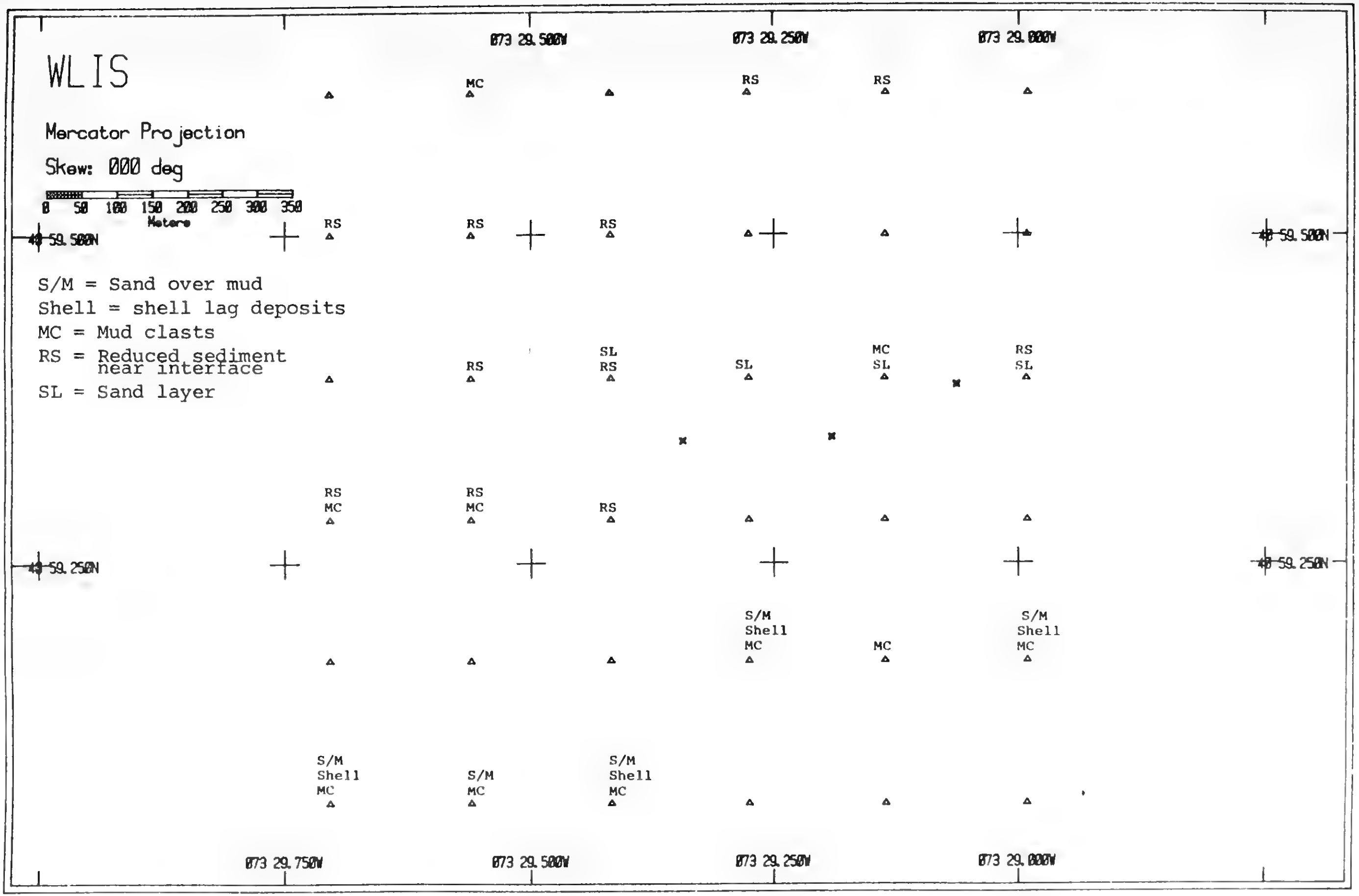


Figure 3-4. The distribution of features indicative of bottom disturbance at the WLIS site in August.

Figure 3-5. A REMOTS image from station 500S/500W showing a sand surface layer overlying silt-clay sediments. Scale=1X

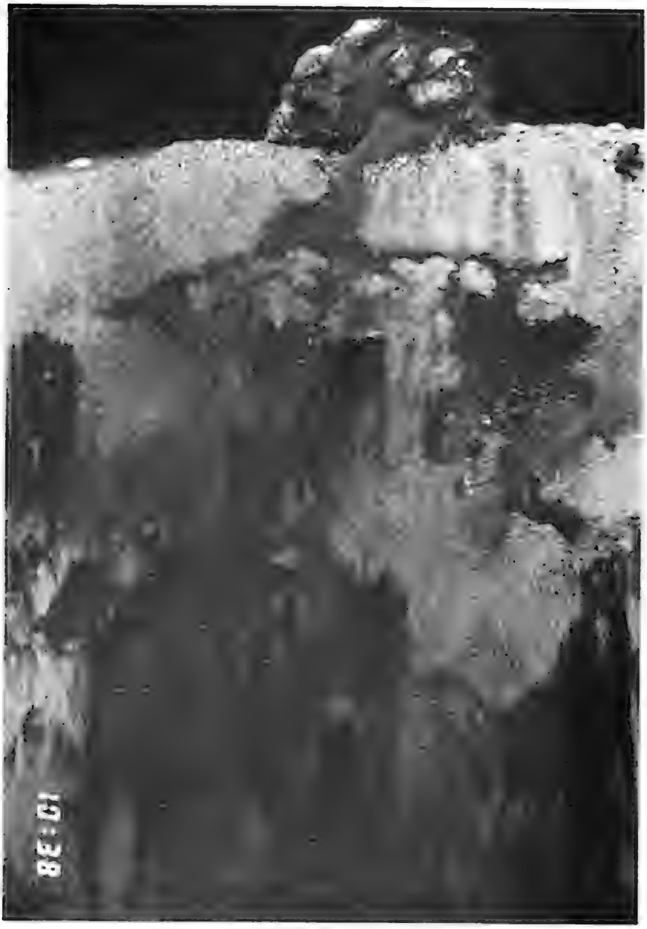


Figure 3-6. A REMOTS image from station 100N/500E showing a chaotic sedimentary fabric, a large mud clast, and coarse-grained sediments at the interface. Scale=1X

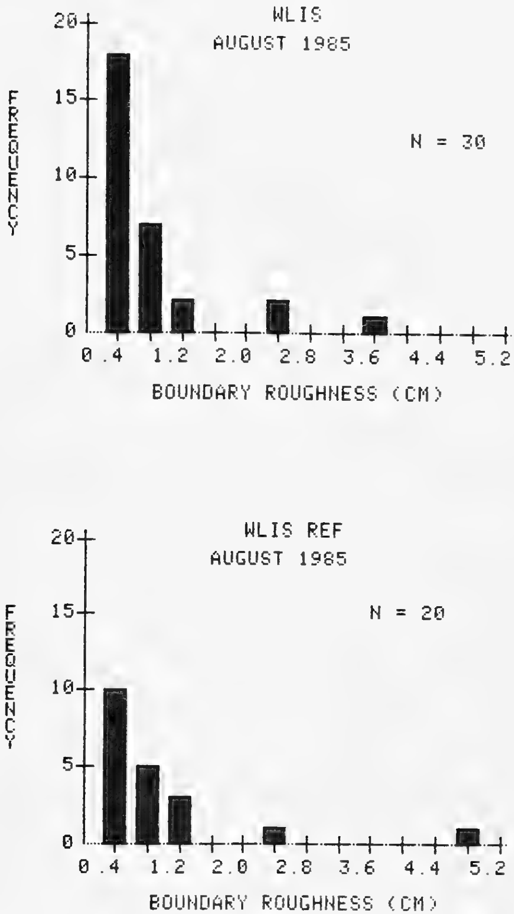


Figure 3-7. The frequency distributions of boundary roughness values for WLIS and WLIS REF in August 1985.

Figure 3-8. A REMOTS image from station 100N/100W showing a reduced sediment patch near the sediment surface. Scale=1X

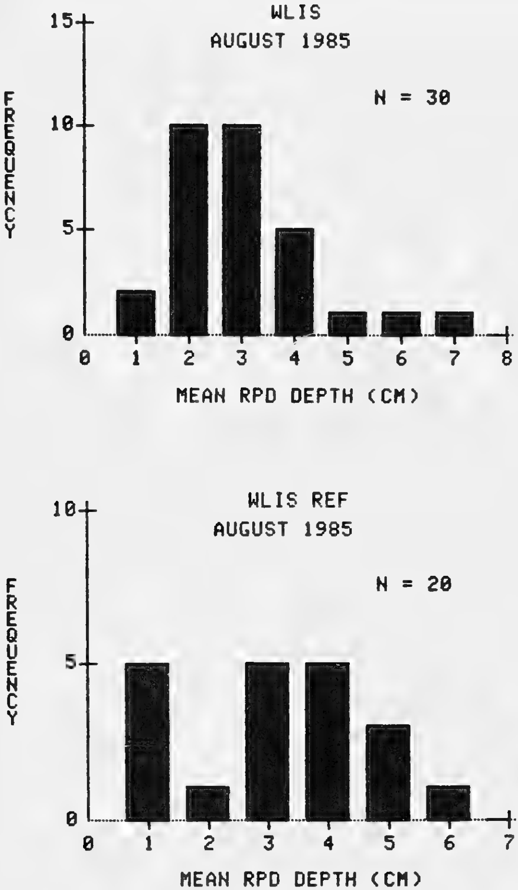


Figure 3-9. The frequency distributions of RPD depths for WLIS and WLIS REF in August, 1985.

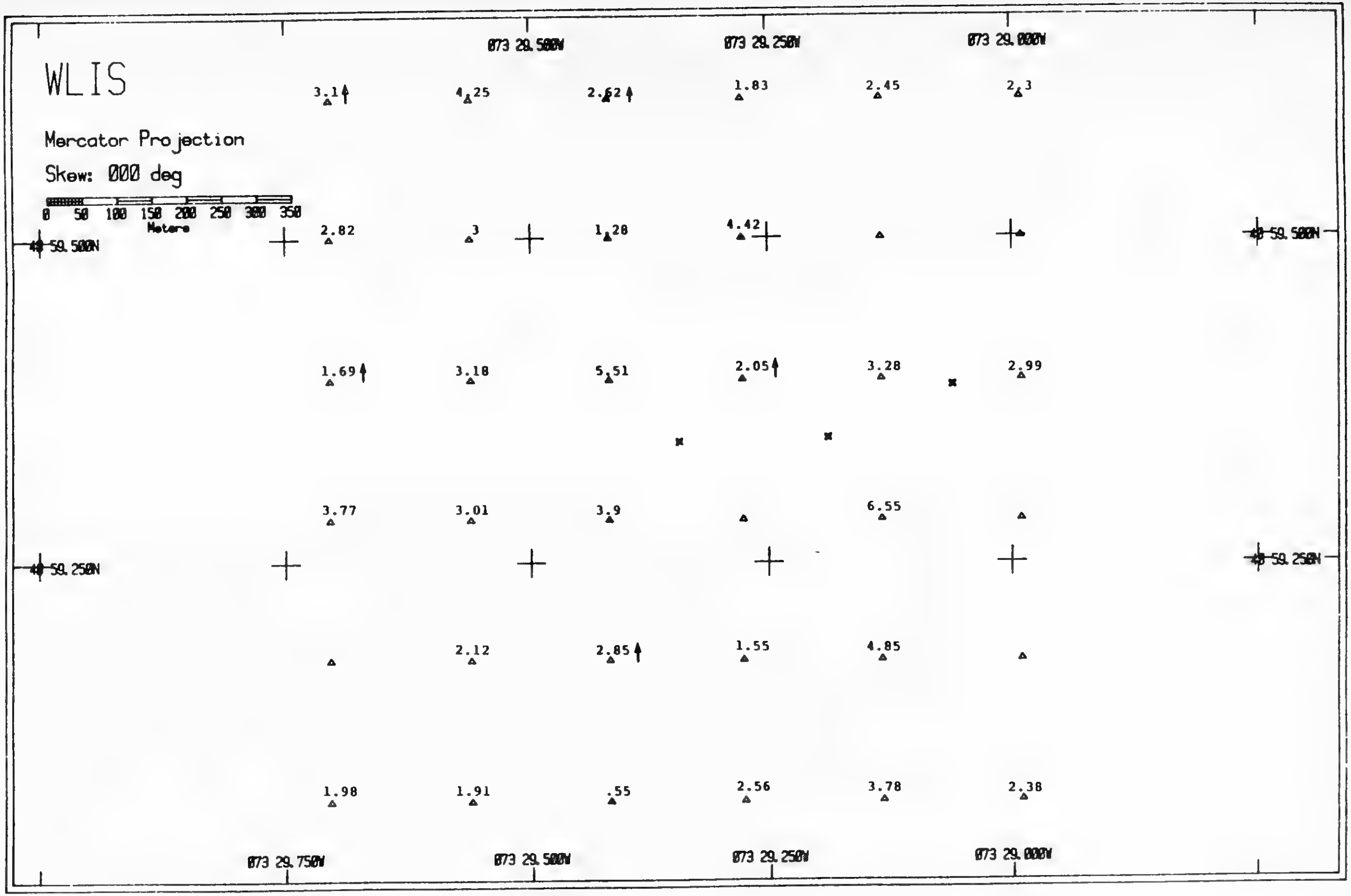


Figure 3-10. The mapped apparent RPD depths (cm) at each station in the August survey at WLIS. The arrows indicate stations exhibiting a rebounded RPD (see Figure 3-11).

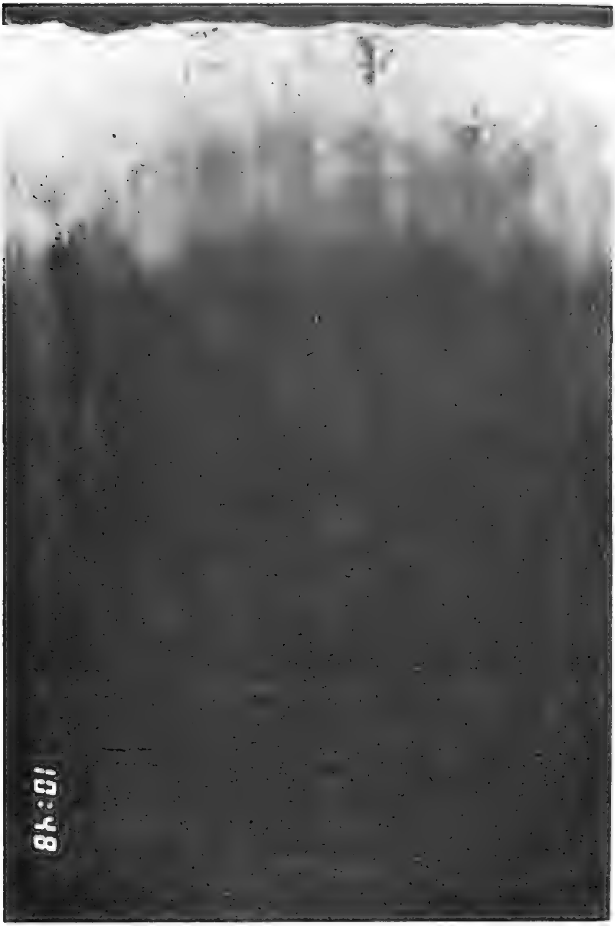


Figure 3-11. A REMOTS image from station 100N/100E showing rebounded RPD, indicative of retrograde conditions. Scale=1X

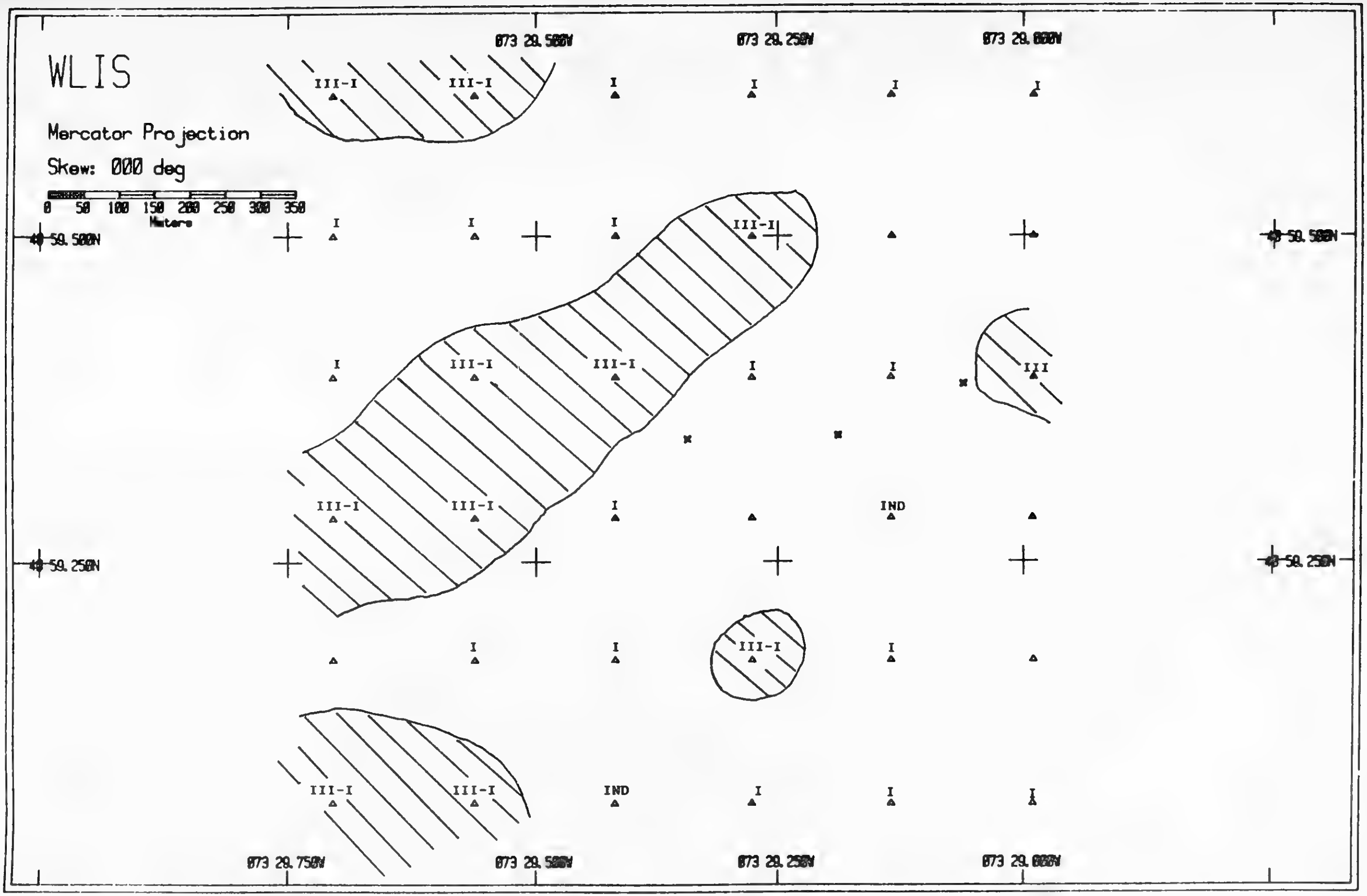
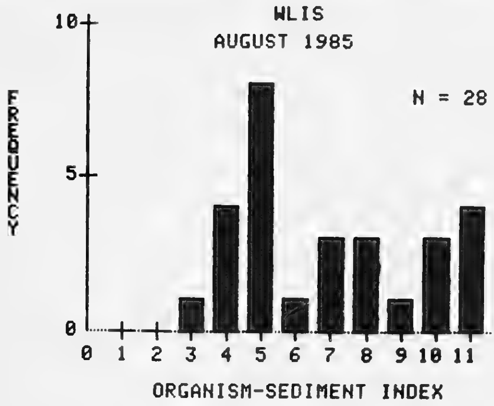


Figure 3-12. The mapped distribution of infaunal Successional Stages for all stations in the August survey at WLIS. Hatching indicates regions dominated by Stage III seres.



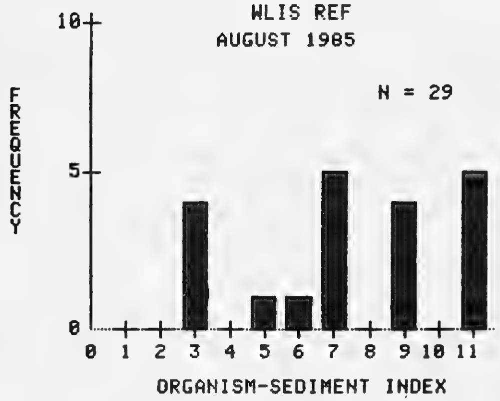


Figure 3-13. The frequency distributions of Organism-Sediment Indices for WLIS and WLIS REF in August, 1985.

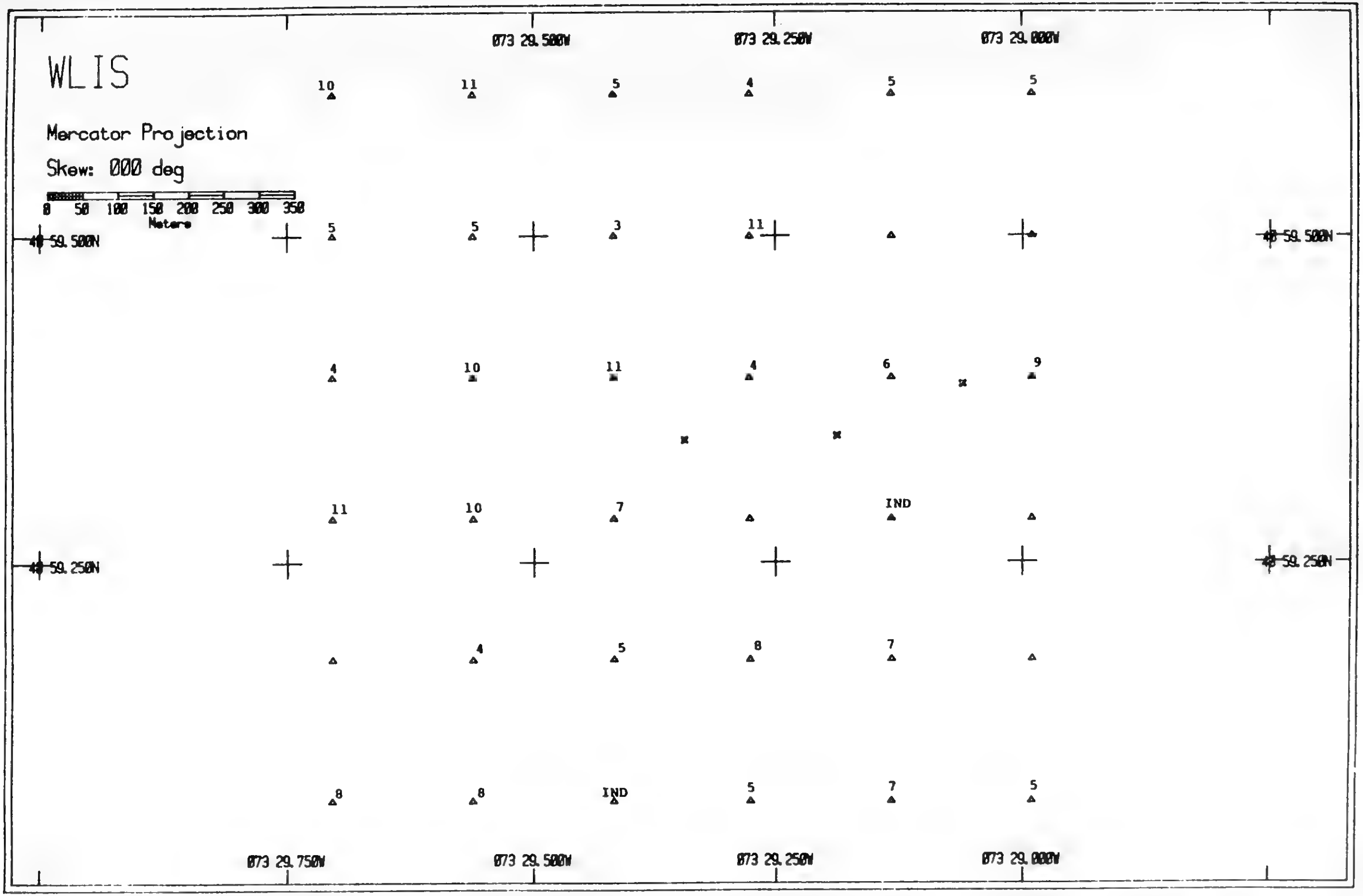


Figure 3-14. The mapped distribution of Organism-Sediment Indices for all replicates in the August survey at WLIS.

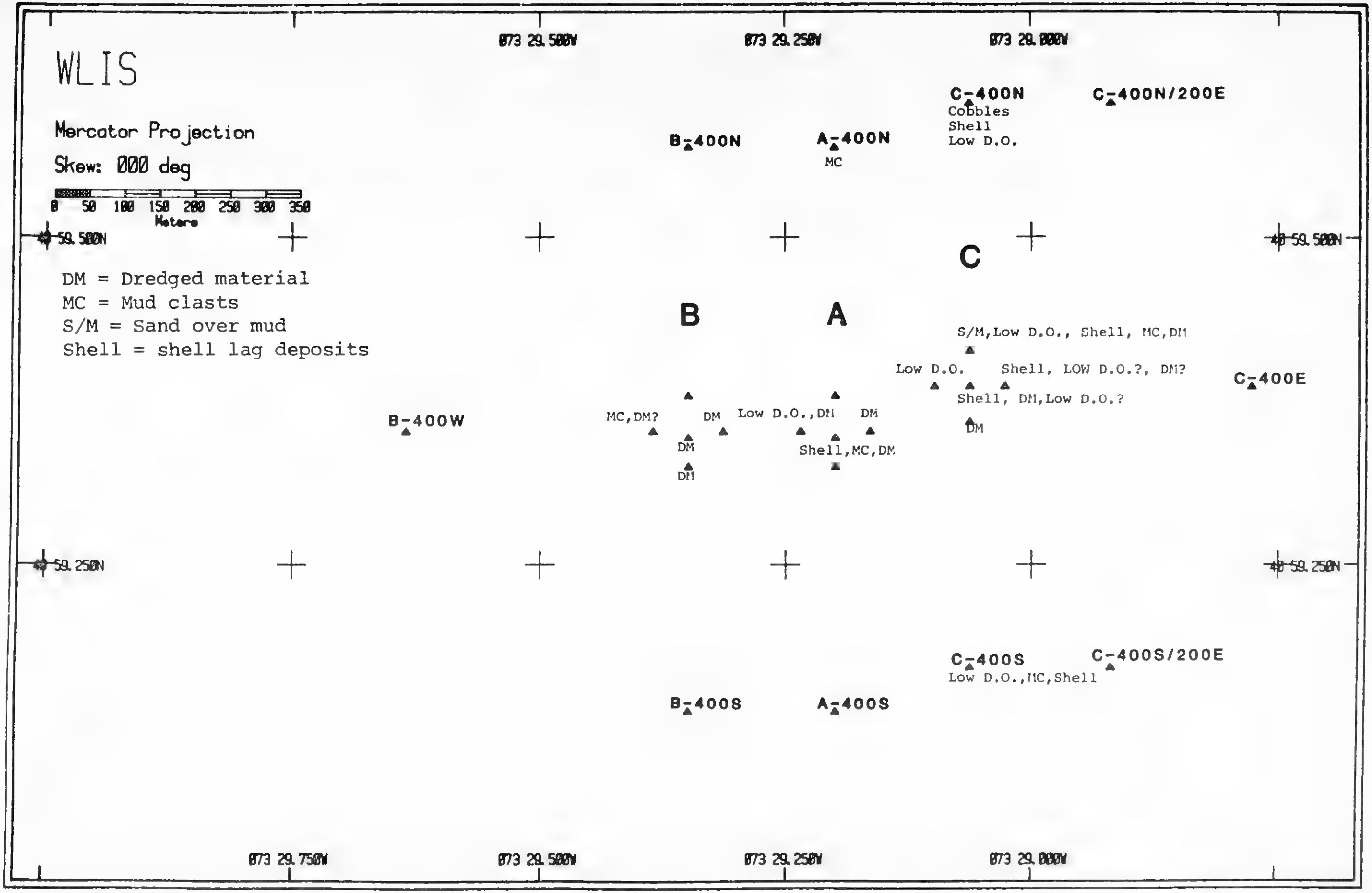


Figure 3-15. The post-storm distribution of features indicative of bottom disturbance at WLIS.

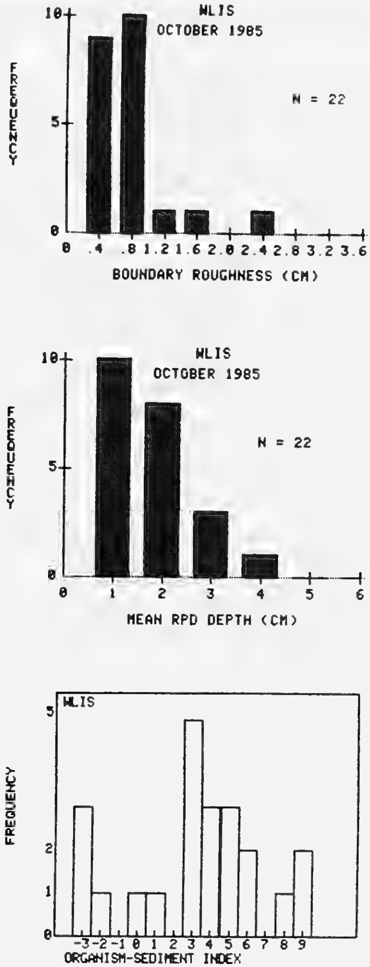


Figure 3-16. The post-storm frequency distribution of Boundary Roughness, Redox Potential Discontinuity, and Organism-Sediment Indices for WLIS.

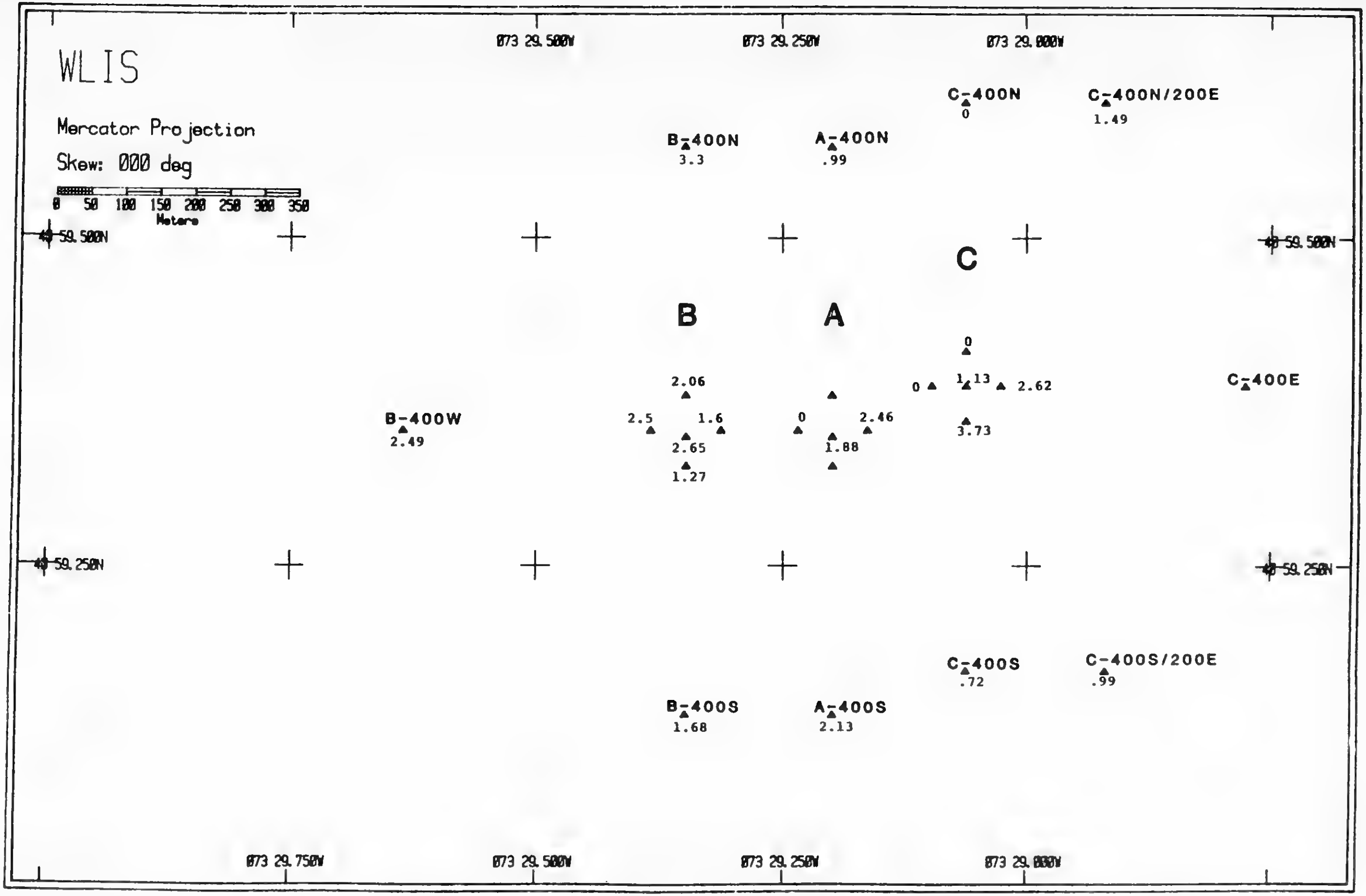


Figure 3-17. The mapped distribution of post-storm RPD depths (cm) at WLIS.

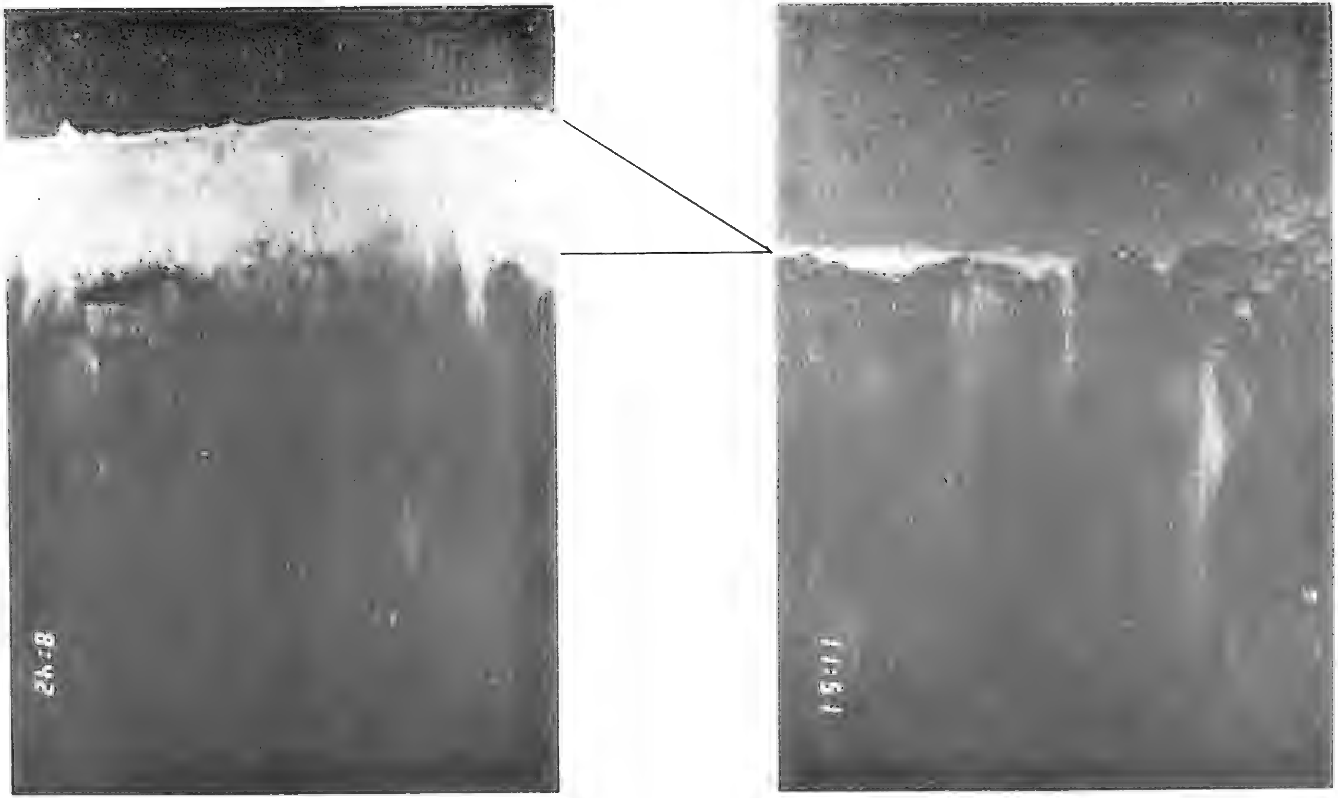


Figure 3-18. REMOTS photos from the FVP site at CLIS, prior to and after Hurricane Gloria.

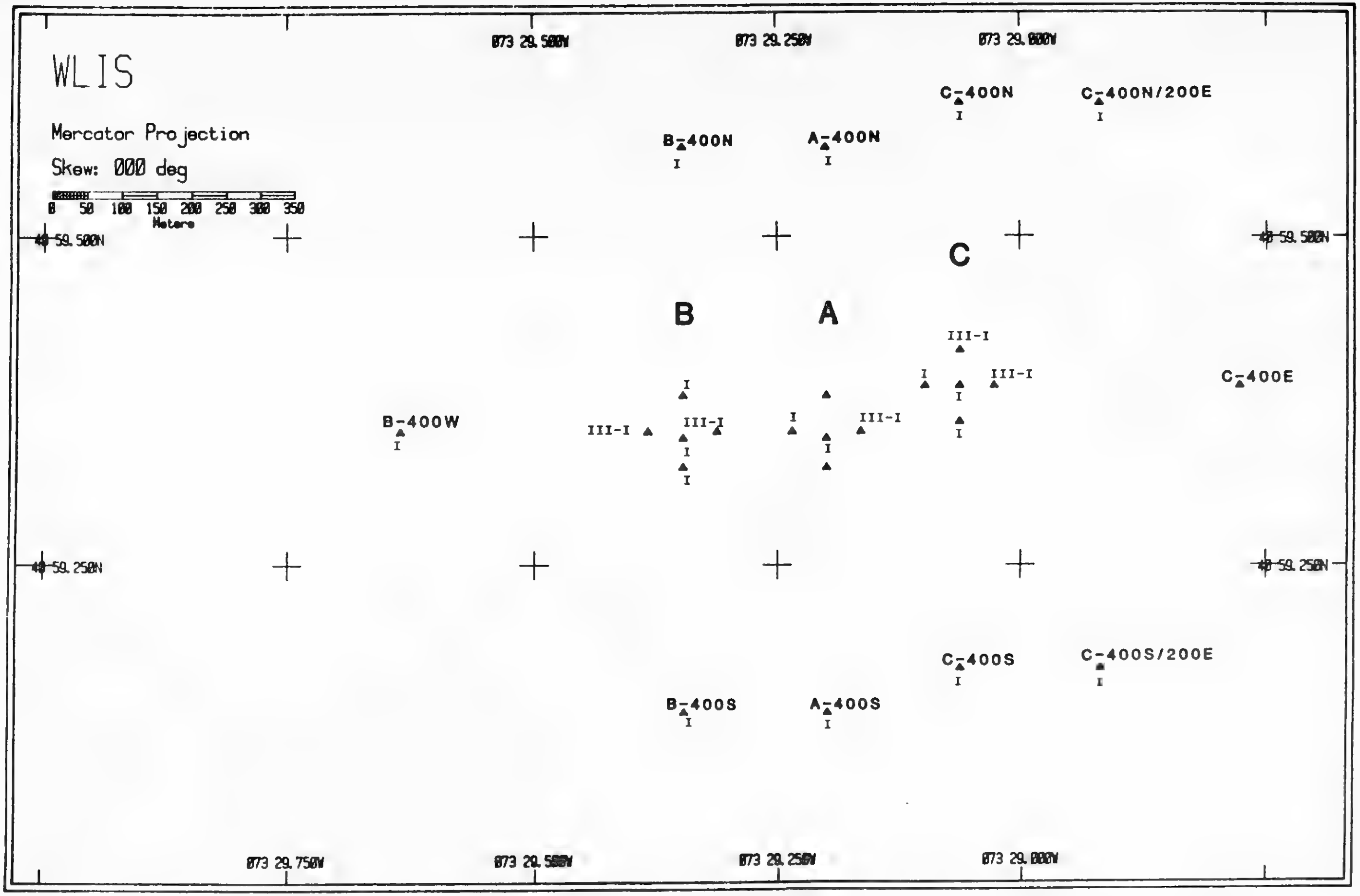


Figure 3-19. The mapped distribution of post-storm infaunal Successional Stages at WLIS.

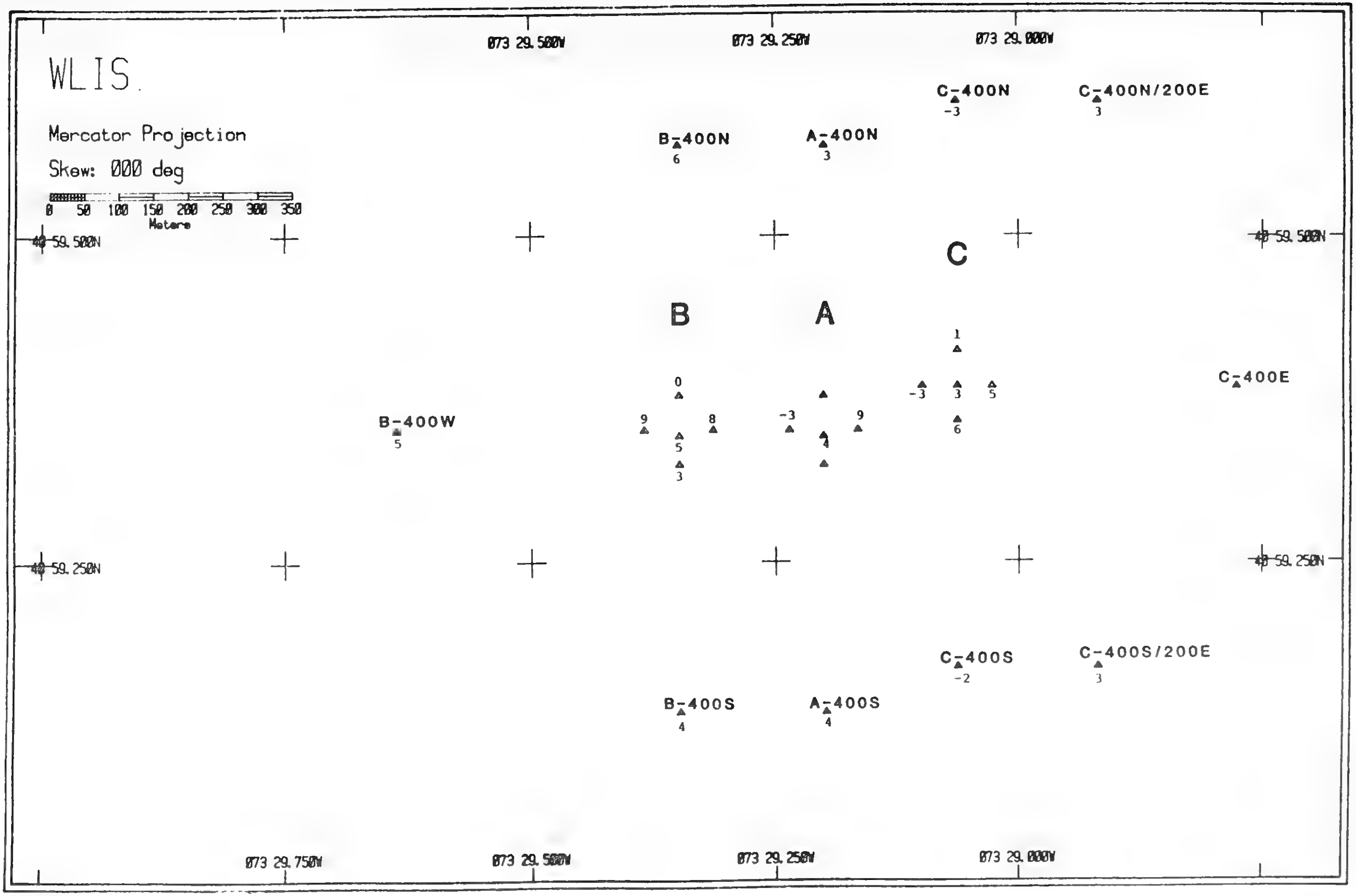


Figure 3-20. The mapped distribution of post-storm Organism-Sediment Indices at WLIS.

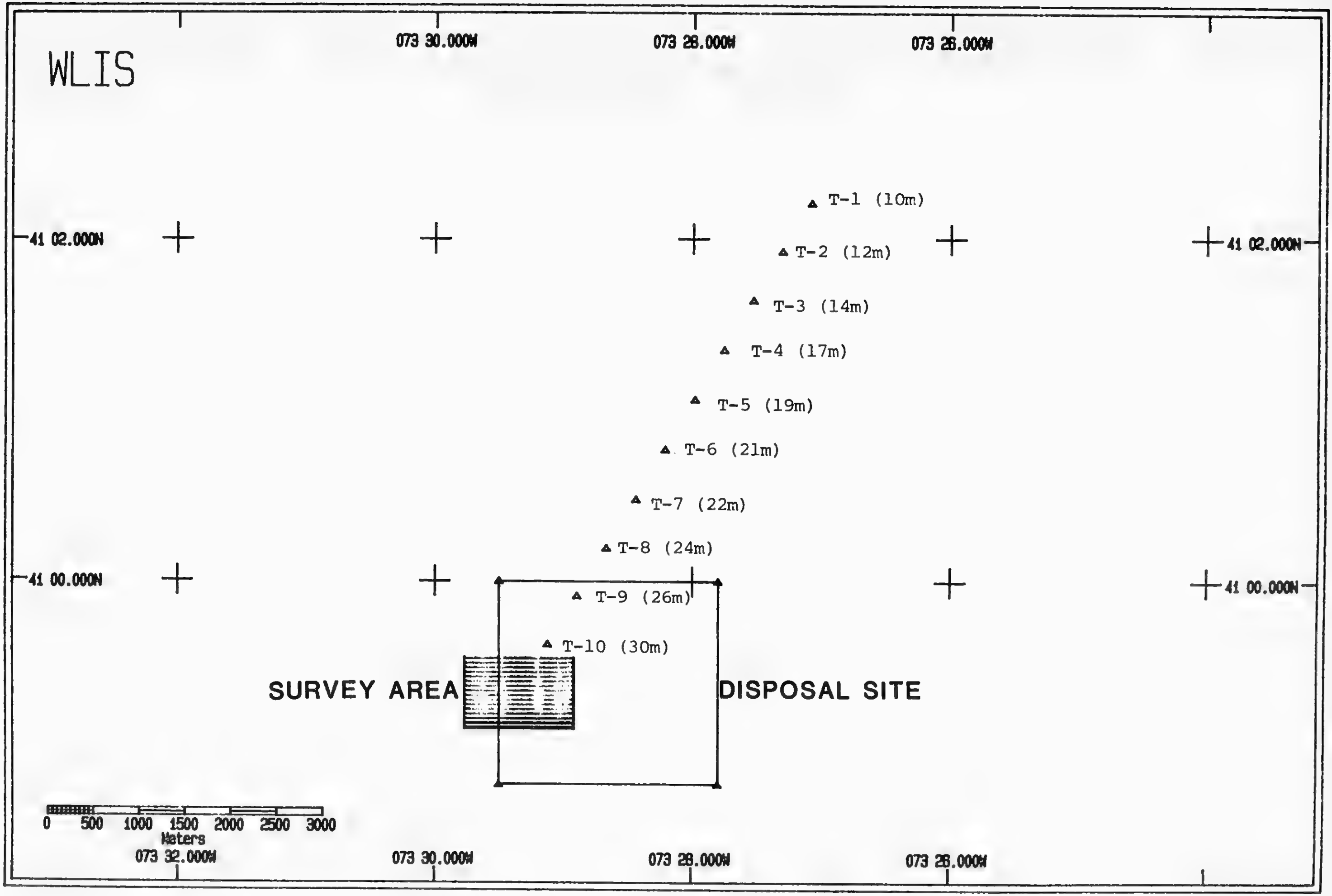


Figure 3-21. Station locations along the WLIS Transect. (Depths in meters).

Figure 3-22. A post-storm REMOTS image from the WLIS transect station T-3 showing evidence of bottom disturbance, shell lag, and an apparently truncated RPD. Scale=1X

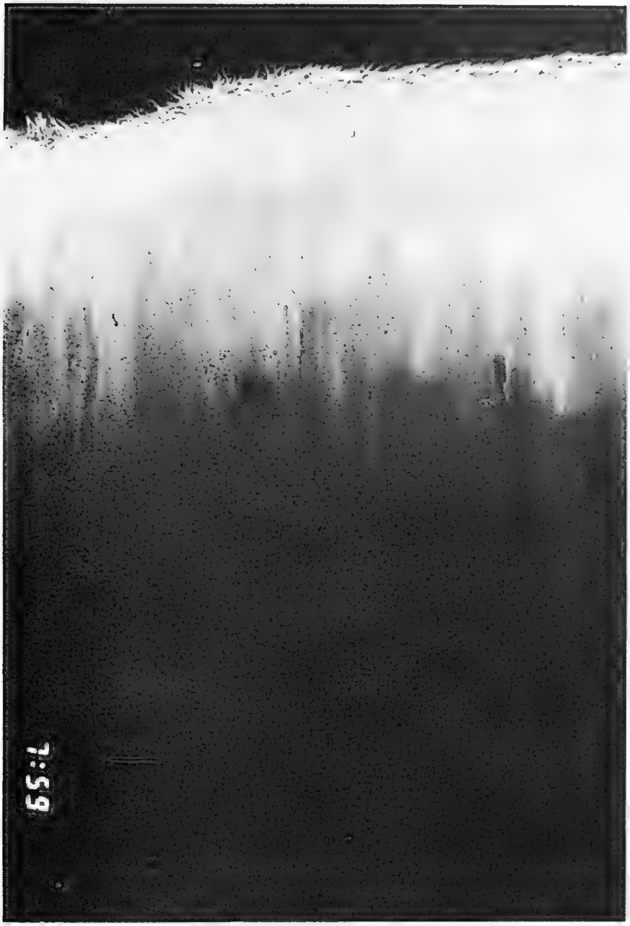


Figure 3-23. A post-storm REMOTS image from the WLIS transect station T-5 showing a smooth bottom with an intact RPD layer and dense Stage I assemblages. Scale=1X

Figure 5-3. Rock crabs excavating burrows under shell material.

Figure 5-4. Two rock crabs use shell for shelter.

Figure 5-5. A juvenile winter flounder among the shell debris.

Figure 5-6. A cunner exhibiting a thigmotactic response to debris on the site.

Figure 5-7. A lobster using concrete debris for shelter.

Figure 5-8. Lobster foraging in open during mid-day.

Figure 5-9. A large hermit crab foraging in loose surficial sediments.

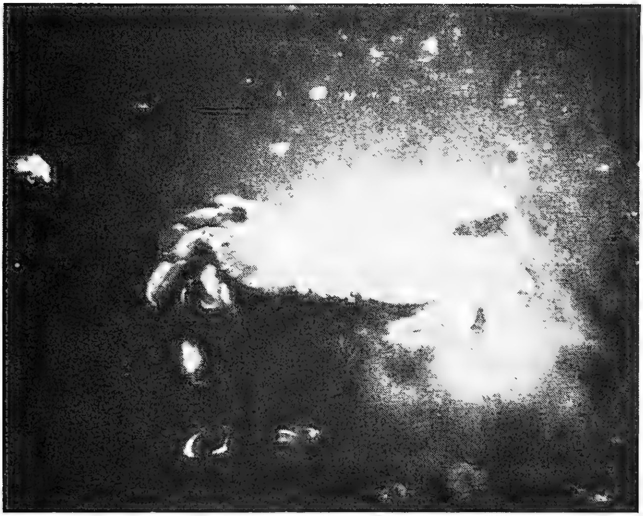


Figure 5-10. A foraging rock crab. Currents move the disturbed sediment in a downcurrent direction.

Table 4-1

Results of Chemical Analysis (ppm) of Sediment Collected at WLIS

SAMPLE	Hg	Pb	Zn	FE	Cd	Cr	Cu	Ni	C:N	O&G
MOUND "B"										
6/84 CTR-1	0.21	178	381	29,200	--	75	119	61	11.4	1070
" -2	0.16	136	297	20,700	--	51	81	46	13.1	557
8/86 CTR-1	0.27	62	143	19,300	0.8	39	69	20	11.2	1120
" -2	0.51	71	173	24,000	2.0	47	91	24	13.4	2430
" -3	0.28	80	172	22,400	2.0	48	84	23	11.1	2350
10/86 CTR	0.30	224	231	29,180	18	60	121	43	--	900
10/86 50m S	0.20	163	187	28,100	<3	50	83	<31	--	710
MOUND "A"										
6/84 CTR-1	0.12	59	241	17,600	4	50	65	36	10.8	72
" -2	0.12	80	361	21,600	4	56	76	54	11.2	10
" -3	0.24	40	426	22,800	3	28	44	36	11.2	89
8/86 CTR-1	0.19	79	162	19,400	4	44	91	24	11.8	1290
" -2	0.30	81	132	16,900	6	57	66	20	15.0	1820
" -3	0.44	141	51	29,800	7.6	54	126	31	13.0	3030
10/86 CTR	0.64	102	112	--	<3	23	40	<31	--	780
10/86 50m S	0.30	76	84	15,000	<3	23	43	<31	--	430

Table 4-1 continued.

SAMPLE	Hg	Pb	Zn	FE	Cd	Cr	Cu	Ni	C:N	O&G
				MOUND "C"						
8/86 CTR-1	0.22	128	43	42,500	2.3	66	151	32	14.2	863
" -2	0.72	78	43	32,900	1.9	75	176	25	13.6	2180
" -3	0.49	82	45	34,500	2.0	55	98	26	13.7	931
10/86 CTR	0.40	141	185	29,600	15	63	124	32	--	500
10/86 50m S	0.10	<28	79	33,800	<3	29	19	<31	--	43
				REFERENCE						
6/84 REF-1	0.07	60	150	24,000	--	47	109	36	13.6	63
" -2	--	61	203	23,300	--	49	40	41	15.3	39
" -3	0.05	57	201	24,900	--	50	32	36	11.8	38
8/86 REF-1	0.30	49	106	24,600	2.6	37	49	27	15.9	1240
" -2	0.28	58	112	20,500	3.6	40	54	33	9.9	2130
" -3	0.19	47	101	24,000	3.1	36	43	29	11.8	253

Table 5-1

Relative Abundances* of Megafaunal Species at the WLIS Disposal Site

	Mound "A"	Mound "B"
Gastropoda		
Busycon carica (Giant whelk)	1	
Loligo pealei (Squid)	6	2
Decapoda		
Cancer irroratus (Rock crab)	>200	>200
Pagurus longicarpus (Hermit crab)	>150	
Pagurus pollicaris (Hermit crab)	4	1
Homarus americanus (Lobster)	2	1
Crangon septemspinosa (Sand shrimp)	1-2/m	
Mysidacea (Shrimp)	12-20/m	
Libinia emarginata (Spider crab)		1
Pisces		
Tautogolabras adspersus (Cunner)	5	
Psuedopleuronectes americanus (Winter flounder)	1	
Peprilus triaranthus (Butterfish)	12	

*Number of individuals recorded by divers while documenting physical and biological characteristics.