Seasonal Monitoring Cruise At The Western Long Island Sound Disposal Site August 1986

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1.0 INTRODUCTION

During the period 7 August to 13 August 1986, field operations were conducted at the Western Long Island Sound Disposal Site to provide information related to the fates and effects of past dredged material disposal operations. The field operations included precision bathymetric surveys, sediment-profile photography (REMOTS®), and sediment sampling for chemical, physical and benthic community analyses. The primary objectives of this study were to:

- Determine if management controls initiated by the New England Division, Corps of Engineers have minimized dispersion of the disposed material and environmental impacts at the site;

- Collect baseline data on body burden levels of selected contaminants for the local benthic fauna within the disposal site for comparison with future monitoring studies.

The Western Long Island Sound (WLIS) disposal area is located 2.5 nautical miles north of Lloyd Point, NY between two previously used disposal sites designated as the Stamford and Eatons Neck disposal 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 area (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. Disposal operations have taken place at the WLIS disposal site since 1982 depositing an average of 153,000 m^3 (200,000 yd^3) of dredged material annually.

2.0 METHODS

2.1 Bathymetry and Navigation

The precise navigation required for all field operations was provided by the SAIC Integrated Navigation and Data Acquisition System (INDAS). A detailed description of INDAS and its operation can be found in Contribution #60 (SAIC, 1986a). Positions were determined to an accuracy of ±3 meters from ranges provided by a Del Norte Trisponder System. Shore stations were established over known benchmarks at Eatons Neck Light and the Norwalk Harbor Power Plant.

The depth was determined to a resolution of 0.1 feet (3.0 cm) using a Raytheon DE-719 Precision Survey Fathometer with a 208 kHz transducer. The fathometer was calibrated with a bar check at fixed depths below the transducer before the survey began. A Raytheon SSD-100 Digitizer was used to transmit the depth values to the SAIC computer system. Survey lanes were run east and west at 25 meter lane spacing over an 800 by 800 meter area centered around the WLIS "A" mound and including the "B" and "C" mounds (Figure 2-1). This lane spacing provides good resolution for subsequent data analysis and the production of detailed depth contour charts.

Analysis of the bathymetric data corrects the raw depth values to Mean Low Water by adjusting for ship draft and for tidal changes for the duration of the survey. All data points in terms of depth and position are checked for unreasonable values due to any malfunctions with the peripheral instrumentation (navigation or bathymetry) so that the final contour plots will not contain errors.

2.2 REMOTS® Sediment Profile Photography

The 1986 WLIS REMOTS® survey was conducted to map the distribution of dredged material and to evaluate benthic habitat conditions and the process of recolonization in the survey area. In 1985, REMOTS® surveys were conducted at WLIS in August (normal survey area) and in October (a post-hurricane "Gloria" survey limited to the vicinity of the three disposal mounds).

REMOTS® images were taken with a Benthos Model 3731 Sediment-Profile Camera (Benthos, Inc. North Falmouth, MA). The REMOTS® camera is designed to obtain in-situ profile images of the top 15-20 cm of sediment. A detailed description of REMOTS® camera operation and image analysis is presented in DAMOS Contribution #60 (SAIC, 1986a).

The WLIS 1986 REMOTS® sampling grid consisted of a 63 station orthogonal grid (7x9) with stations equally spaced 100 meters apart (Figure 2-2). Three replicate images were obtained at each station. In addition, twenty REMOTS® images were obtained at the WLIS Reference station (40°59.70N, 73°27.75W). Of the three REMOTS® replicate images obtained at each station, one was analyzed for this report and two were archived for possible future analysis. Twenty replicate images from WLIS Reference were analyzed for this report.

2.3 Sediment Sampling and Analysis

Triplicate sediment samples were collected at the WLIS "A" disposal mound and the Reference station using a 0.1 m^2 Smith-McIntyre Grab Sampler. Six polycarbonate plastic core liners (6.5 cm ID) were pushed into the sediment grab sample and extracted; the six cores were combined and placed into bags for subsequent chemical and physical analysis by the NED laboratory. The top 2 cm of the cores were bagged for separate analysis to determine whether the surface sediment was relatively more or less contaminated than the deeper sediment due to the desorption of contaminants or the deposition of cleaner material. The samples were kept cold and returned to the NED laboratory where they were stored at 4°C until analyzed. Parameters measured included grain size, trace metals, and several organic constituents.

Sediment analyses were conducted using methods described by the U.S. Environmental Protection Agency (Plumb, 1981). Mercury analysis was performed using acid digestion and cold vapor atomic absorption spectrophotometry; arsenic analysis was accomplished using acid digestion and gaseous anhydride atomic absorption spectrophotometry. The other trace metals (As, Pb, Zn, Cr, Cu, Cd, and Ni) were analyzed using acid digestion and flame atomic absorption spectrophotometry.

Carbon, hydrogen, and nitrogen analyses were conducted with an autoanalyzer using a combustion technique. Oil and grease measurements were made by extracting the sediment with freon and then analyzing the freon by infrared spectrophotometry. PCBs were extracted with hexane and also analyzed by electron capture gas chromatography.

2.4 Benthic Community Analysis

Quantitative benthic samples were obtained with a Smith-McIntyre grab at the center of the WLIS "A" mound and the Reference station. Five sediment samples were collected and sieved onboard the research vessel through nested 2 and 0.5mm mesh screens. The material retained on the sieves was preserved with buffered formalin for later sorting and identification in the laboratory. Only three of the samples from each of these stations were analyzed while the remaining two were archived for future reference if necessary. A small subsample of each grab was collected for grain size analysis by the NED laboratory using a 3.0 cm inner diameter core tube. A visual description of each sediment grab was recorded prior to sieving. In the laboratory, benthic samples were stained with 0.2% rose bengal and sieved on 1.0 and 0.1 mm screens immersed in water. All samples were analyzed under the supervision of Mr. Sheldon Pratt at the University of Rhode Island.

The samples collected at the center of the "A" mound had a large volume of homogeneous organic detritus and a large number of polychaetes and polychaete fragments in the fine low-density fraction. Following a technique used with similar samples from the EPA/COE Field Verification Program, this fraction was divided with a plankton splitter and one-half counted. Because of the large numbers of polychaetes recovered and the homogeneity of the samples in terms of species composition, one half was considered to give an adequate representation of the assemblage present and is the basis of the counts given here. The remaining half was sorted and counted to provide a check on the technique for possible inclusion in future WLIS monitoring plans.

Organisms were identified to species in most cases. Individuals from all fractions were combined during counting. All individuals were stored in 70% alcohol. Sieve residues were described in laboratory notes and discarded. A combined reference collection was made of all species found in 1986 Central and Western Long Island Sound disposal site samples and is being maintained at the University of Rhode Island, Graduate School of Oceanography.

2.5 Body Burden Analysis

The test organisms for body burden analysis were collected at the Reference station and at the WLIS "A" mound with the Smith-McIntyre grab. Sediment was sieved through a 2mm mesh and the deposit-feeding organisms (the polychaete Nephtys incisa) were isolated and placed in seawater at ambient temperature. Sufficient biomass was collected for triplicate analyses. The animals were allowed to purge their gut contents for 24 hours before they were frozen and transported to the laboratory for chemical analysis. The polychaetes were analyzed for eight trace metals and PCBs. These analyses were conducted by the SAIC laboratory in La Jolla, California. A detailed description of the methods used for the analysis of the polychaete tissue can be found in DAMOS Contribution #60 (SAIC, 1986a).

The PCB analyses were quality assured by measuring the recovery of a surrogate compound (dibutylchlorendate) in each sample. The recovery of this compound was 62% ±9 for the Western Long Island Sound Disposal Site samples.

3.0 RESULTS

3.1 Bathymetry

The minimum depths for the three disposal mounds "A", "B", and "C" (Figure 3-1) are 29.25, 32.5, and 27.75 meters, respectively. These minimum depths were found during the October 1985 survey (Figure 3-2) to be 29.25, 32.5, and 28.5 meters, respectively. This change in bottom topography at mound "C" was the result of disposal operations occurring there between 30 October 1985 and 8 August 1986. Tabulation of scow logs for this period indicate that approximately 73,230 cubic meters (95,730 cubic yards) of dredged material were deposited at or near the buoy location. The scow logs also indicate that individual scow loads were dumped up to 200 meters from the buoy in all directions although the average distance to the buoy was closer to 50 meters. Comparison of Figures 3-1 and 3-2 reveals a significant decrease in depth at mound "C" as well as the west flank of "C" and the northeast flank of mound "A". These areas are well within the scope of the recent disposal operations.

Volume difference calculations conducted for the October 1985 and August 1986 surveys estimated the amount of dredged material deposited to be approximately 35,700 cubic meters. Much of the large difference in this volume estimate from the scow log estimate (73,230 m^3) can be attributed to the methods of estimation. The scow log estimates are derived from the draft of the loaded scow. The scow typically holds a large volume of water collected with the dredged material. This leads to an overestimate of the total amount of material. The volume difference calculations are based on acoustic measurements that can reliably detect differences in depth of approximately 10-15 cm. The amount of material at the flanks of the mound in layers less than this can be significant and therefore causes an underestimate of dredged material deposited. This effect can be more pronounced when environmental factors, such as weather, reduce the positioning capabilities of the disposal scows. In addition, the effects of the loss of interstitial water from the dredged material during descent and compaction once on the bottom will contribute to the difference in volume estimates (see Section 4.1 for further discussion).

To determine the significance of this estimated deposit of material, the statistical error of this estimate was calculated for the WLIS survey area. A detailed description of the calculations required to determine this error and the 95% confidence limits around it can be found in DAMOS Contribution #60 (SAIC, 1986a). For the present volume difference calculations of the 800 × 800 m survey area, the standard error was determined to be 6720 m^3. To insure the reliability of this estimated volume difference, 95% confidence limits were calculated and resulted in a range of 22,530 to 48,870 m^3. This calculation simply implies that the actual (and unknown) volume difference will occur within these limits with a probability of 0.95.

3.2 REMOTS® Sediment-Profile Photography

As observed in previous REMOTS® surveys within the WLIS disposal site, most of the survey area was dominated by silt-clay (> 4 phi) sediments (Figure 3-3). However, a cluster of 6 stations on and east of mound "C" consisted of very fine, fine, and medium sands. Figure 3-4 shows the distribution of sandy sediments across the survey area. Distinct sand layers, either at the surface or buried, were evident throughout the northern and eastern half of the region (Figure 3-5). Mounds "A" and "B", composed predominately of silt-clay, also exhibited some near-surface layers of sand. Based on this distribution, the sands appear to represent dredged material deposited since the last complete survey of this area in August 1985. This inference is also supported by the lack of sand layers in images from the western portion of the survey area and from the WLIS Reference station. All replicates collected at the WLIS Reference station exhibited a major mode of silt-clay (> 4 phi).

Dredged material layers (Figure 3-6) deposited since 1985 were readily detected when dredged material thickness was less than the prism penetration depth (20 cm). This was because the relatively high-reflectance, pre-disposal interface was evident below the low-reflectance dredged material (Figure 3-7). This high-reflectance material could be either natural bottom or previously deposited dredged material that had developed a deep RPD layer. The pre-disposal interface was not evident in many of the images from the region around disposal mound "C" indicating that dredged material layers were at least 20 cm or greater throughout this area. Overall, dredged material was widespread in the area surveyed. Only the southern portion of the site lacked readily discernible dredged material layers.

At the Reference station, thirty-five percent (7 of 20) of the images showed subsurface low-reflectance layers overlying high-reflectance sediments. These layers do not sharply contrast with adjacent sediments and are generally discontinuous. They are inferred to represent relict dredged material (i.e., material disposed of a number of years ago). Recently deposited dredged material would be expected to contrast more sharply with the buried pre-disposal interface. Similar dredged material layers were observed at the Reference station in 1985 and 1984. At those times, it was also concluded that this material represented relict dredged material deposited in an historically-used disposal site in that area (Eatons Neck). REMOTS® images were not obtained at the WLIS reference site prior to 1984.

A process map of the survey area shows the distribution of features which are indicative of bottom disturbance (Figure 3-8). For example, many stations showed the presence of low reflectance (black) sediment at, or near, the sediment surface. This reduced sediment appears to have its origins from below the high reflectance (ferric hydroxide) bioturbated zone as either a layer or discrete mud clasts (Figures 3-7 and 3-9). Oxidized mud clasts were also present in many images. Surface patches of reduced sediment (which were also observed in the August 1985 WLIS survey) were likely produced by predator excavation and/or bottom scour. The depth of excavation or scour need not be great to expose this reduced material to the interface because RPD depths are shallow (< 2.0 cm) over much of the area. Methane gas pockets were observed at depth in the sediment at station 3-D (Figure 3-10). The presence of methane is an indication of high sediment oxygen demand (SOD). Surface shell lag deposits, produced by physical bottom scour, were observed in 5 images. In general, evidence of small-scale physical and biogenic bottom disturbance was widespread. This is similar to the pattern observed during the post-"Gloria" REMOTS® survey in October 1985. The relative frequency distributions of surface boundary roughness values at the WLIS survey area and WLIS Reference are shown in Figure 3-11. The major mode was 0.80 for both regions. This represents an increase in small-scale surface roughness since August 1985 when the major modal value was 0.4 cm. This may reflect the impacts of Hurricane Gloria on the region.

The mean apparent Redox Potential Discontinuity (RPD) frequency distribution for the survey area (Figure 3-12) is bimodal with modes centered at 1.0 cm and 3.0 cm. The mean RPD depth was 2.16 cm. The WLIS Reference RPD distribution is skewed right with the major mode at 1.0 cm, and a mean value of 0.59 cm. RPD depths at WLIS Reference were significantly shallower than RPD depths at the survey area (Mann-Whitney U-test, $p < 0.001$). This pattern is noteworthy and suggests that the "disturbance" factors affecting the WLIS Reference station were more severe than the effects of the dredged material disposal operations occurring within the WLIS survey area. At the WLIS survey area, RPD depths have shallowed significantly since August 1985 (ANOVA, $p = 0.004$); suggesting an increase in oxygen depletion in the region. The mapped distribution of mean RPD depths is shown in Figure 3-13. The hatched areas exhibited RPD values greater than 3 cm. In general, these areas were restricted to the edge of the survey area. Most of the region was represented by RPD values between 3 and 1 cm. Based on past experience, values less than 1 cm represent highly stressed habitats. The largest highly-stressed area extended N-S through the area occupied by mounds "A" and "C"; this likely reflects the influence of recent disposal operations. Another area of low values existed adjacent to mound "B".

The location of the three disposal mounds appears to "straddle" regions of both Stage I and Stage I-III successional seres (Figure 3-14). Stage III seres occurred in three large patches in the eastern, southern, and north-central portion of the survey area. Comparison of Figures 3-14 and 3-13 reveals a poor correspondence between Stage III seres and deep RPD's. This pattern may indicate that a retrograde successional condition was being caused by reduced rates of bioturbation (possibly due to seasonal hypoxic conditions). About half of the WLIS survey area stations and 70% of the WLIS Reference replicates exhibited a Stage I assemblage. Again, this pattern suggests that, overall, the WLIS Reference station was more highly stressed than the active disposal area. In August 1985, the distribution of Stage III seres was much less widespread in the eastern portion of the region.

Based on the results of past REMOTS® surveys, Organism-Sediment Index (OSI) values of +6 or less are considered to indicate that the bottom is stressed or has experienced recent disturbance (erosion, dredged material disposal, hypoxia, or demersal predator foraging). The polymodal OSI frequency distribution of the WLIS survey area (Figure 3-15) indicates a mosaic of past disturbances (the major mode at 6 and 7, subordinate modes at 3 and 9). The WLIS Reference site had a major mode at -3, and no values exceeded +5. OSI values for the WLIS survey area were significantly greater than the WLIS Reference OSI values (Mann-Whitney U-test, $p < 0.001$). Even relative to the WLIS survey area, WLIS Reference appeared to be a highly stressed region. The mapped distribution of OSI values (Figure 3-16) shows a region of relatively high OSI's to the east of the site and to the north and west of the disposal mounds. The apex of disposal mound "B" exhibited relatively high, but variable, OSI's. Mound "A" was bounded on the south by an area of high indices. The center of mound "C" was associated with the lowest mapped OSI value (-2); this illustrates the impacts of recent disposal operations. The overall pattern of OSI values consisted of high and low values in close proximity to one another. This appears to reflect both the influence of disposal operations as well as disturbance factors (unrelated to disposal) prevalent in western Long Island Sound in general.

3.3 Sediment Characteristics

Results from the chemical analysis of the sediment samples are presented in Table 3-1. Each individual result and the means and standard deviations are presented for the Top and Bottom sections of each core. The exception to this is PCBs for which only one composite sample was analyzed from each station.

Statistical tests were performed to determine if the contaminant concentrations were different between stations.

Also, the contaminant concentrations of the Top and Bottom sections of the cores were compared. The Kruskal-Wallis test was used for comparing concentrations to detect significant differences at the $p < 0.05$ level.

Results of the statistical analyses showed that in the cores from the Reference station, the concentration of chromium was significantly higher ($p<0.05$) in the Top sections whereas those of iron were significantly higher in the Bottom sections. In the WLIS-A station cores, concentrations of lead, nickel, copper, and oil and grease were significantly higher in the Top sections compared to the Bottom sections. The concentrations of these same four elements were significantly elevated in Top sections of the WLIS-A cores compared to those of the Reference station cores.

The physical characteristics were determined for the sediment collected for the benthic community analysis (Table 3-2). The sediment from all five samples obtained at the "A" mound center was described as dark gray silty sand with some gravel and/or shell fragments. The sediment from the Reference station was much finer material dominated by dark, olive gray organic clay with shell fragments.

3.4 Benthic Community Analysis

The sieve residues from the Reference station samples consisted of 500-1,200 cm^3 of shells and shell particles. Intact shells of bay scallop (Aequipecten irradians), soft shell clam (Mya arenaria), gem clam (Gemma gemma), juvenile surf clam (Spisula solidissima), and mud snail (Ilyanassa obsoleta) all suggest an origin in shallow sandy bottom. Coot clam (Mulinia lateralis) shells were also present, but are less indicative of origin. The samples contained a small amount (approximately 20 cm^3) of fine organic debris.

Samples collected at the center of "A" mound contained 3000-4000 cm^3 of sand and pebbles and about 100 cm^3 of coarse plant debris. Smooth white quartz pebbles were a conspicuous constituent. Bits of coal, boat paint, and rust could be seen under magnification. Table 3-3 presents the visual descriptions of the sediment grabs collected at both WLIS-A and the Reference station for benthic community analysis.

Species counts are given in Table 3-4. A summary of the number of species and individuals in major taxa at each station is given in Table 3-5. The number of species present at the two stations follows a pattern found at other disposal sites. Species richness is lower at the Reference station than at the WLIS-A station. At both stations, polychaetes were the most abundant taxon followed by molluscs and crustaceans.

Density of individuals was higher at the WLIS-A station than at the Reference station (mean/sample 1421 vs. 584, Table 3-5). Most of the individuals at the WLIS-A station were polychaetes with a mean density per sample of 1264 (89% of the individuals). There were nearly equal numbers of polychaetes and molluscs in the Reference samples. Crustaceans were found at low densities at both stations (2.2 and 2.3% of individuals).

The dominant species at the WLIS Reference station are characteristic of the deep silty bottoms of Long Island Sound. The polychaetes Nephtys, Mediomastus, Sigambra, and Cossura; the bivalves Nucula and Yoldia; and the anemone Ceriantheopsis all also appear in samples collected at the reference station at the Central Long Island Sound (CLIS) disposal site. Excluding Mediomastus, these species were absent or found in lower numbers in the WLIS -A station samples. The densities of dominant species at the WLIS Reference station were less than are usually found at CLIS and included few mature individuals.

The WLIS-A station had over 20 species which were notably more abundant than at the Reference station. These included species requiring solid surfaces for attachment (e.g., the polychaete Sabellaria, the gastropod Crepidula) and many tube dwellers or burrowers requiring silty sand or sandy substrate (e.g., the polychaetes Pherusa, Pectinaria, Euclymene, Ampharete; the amphipod Leptocheirus; the bivalves Ensis, Tellina). In addition, some species present are characteristic of shallower, less saline, more variable environments (e.g., the polychaetes Polydora ligna and Nereis succinea).

3.5 Body Burden Analysis

Triplicate samples of Nephtys incisa from both the WLIS-A and Reference stations were analyzed for eight inorganic elements and several PCB formulations. Concentrations were calculated on both a dry weight and wet weight basis for comparisons with literature values and FDA action levels. Statistical analyses (Kruksal-Wallis test) were conducted on the results to test the difference between concentrations found in organisms collected at the two stations, with the exception of PCB's which were below the analytical detection limits. Results of the inorganic analyses are presented in Tables 3-6 and 3-7 and the PCB results are shown in Table 3-8.

The results from the statistical analyses of the inorganic data showed that the concentration of lead in the Nephtys collected from the WLIS-A station were significantly higher ($p<0.05$) than in those collected from the Reference station. Zinc and cadmium concentrations were significantly higher in the Reference Nephtys compared to the levels in the polychaete collected at the WLIS-A station.

4.0 DISCUSSION

4.1 Bathymetry

Results of the bathymetric surveys conducted at the WLIS disposal site indicate that dredged material is accumulating at the designated disposal point between mounds "A" and "C". The volume of deposited dredged material estimated from scow logs was 73,230 m^3. The volume difference calculated from the bathymetric surveys in October 1985 and August 1986 was 35,700 ± 6720 m^3, or 49% of the scow log estimate. The difference in the two estimates is partially due to the overestimates from scow logs due to unknown amounts of water in the scow. In addition, dredged material at the flanks of the mound can occur in thin layers that are undetectable acoustically. Finally, compaction of the material on the bottom prior to the post-disposal bathymetric survey can significantly affect the estimate of the volume of deposited material.

A study was conducted by the New York District of the Corps of Engineers in 1980 at the Mud Dump Site in the New York Bight to determine the loss of dredged material from the initial dredging to disposal (Tavalaro, 1983). A comparison of carefully determined volumes of dredged material in the scows with the volume of material deposited at the disposal site, determined by pre- and post-disposal bathymetric surveys, indicated a loss in volume of approximately 40.7%. Of this total, a volume loss of 15.4% was attributed to the dispersal of interstitial water during descent. It also has been estimated that approximately 7% can be attributed to compaction of the material once on the bottom (Bokuniewicz et al., 1980). Bokuniewicz et al. has determined that 50% of the total compaction will occur within one month of disposal and 100% within one year. Of the total loss in volume of 40.7% determined at the Mud Dump Site, approximately 18.3% (or 40.7% - 15.4% - 7%) of the loss in volume was unaccountable. This loss is likely due to dredged material being deposited in thin layers that can't be detected acoustically.

4.2 REMOTS® Sediment-Profiling

The major objectives of the present REMOTS® survey were to document the distribution of dredged material in the WLIS survey area and to document the process of recolonization on the new and existing disposal mounds. As observed in the surveys conducted in 1985, dredged material was widespread in the surveyed area (Figure 3-6). Dredged material layers were distinct and relatively thick, often consisting of coarse-grained sediments, in the eastern portion of the survey area and apparently represent materials deposited at the present disposal point since the last complete REMOTS® survey in August 1985. This dredged material may extend somewhat east and northeast of the area surveyed. However, because the survey area was approximately 1600 meters west of the eastern boundary of the WLIS Disposal Site (Figure 2-1), this dredged material is likely contained well within the disposal site. In general, the dredged material observed in the western portion of the survey area was fine-grained and did not exhibit a sharp contrast to the surrounding sediments in terms of its reflectance and many of the layers were discontinuous (Figure 4-1). This "weathered" dredged material apparently represents sediments deposited in past years (at points "A" and "B").

Dredged material was also detected in 35% (7 of 20) of the WLIS Reference images. In August 1985, dredged material was observed in 50% of the Reference images. Based on its very low-contrast optical signature and discontinuous layering (Figure 4-1), this sediment is inferred to represent relict dredged material. The Reference station is located near the edge of an historically-used disposal site (Eatons Neck). These inferences regarding "relict" dredged material are further supported by the lack of sandy sediments at the Reference station. Sands were concentrated only around disposal point "C". Based on scow logs, this coarse-grained material represents the most recently deposited material. The placement of the WLIS Reference station near a previously-used disposal site (Eatons Neck) is the unavoidable result of several constraints encountered during station designation. These constraints included locating a station near the WLIS Disposal Site of comparable water depth, bottom topography, and sediment type. In addition, several formerly used disposal sites are present in the region. Consequently, an area satisfying the above environmental criteria that did not occur in or immediately adjacent to an historic disposal site could not be found.

Some infaunal recolonization of the survey area has occurred between the 1985 and 1986 surveys. Stage III taxa were more widespread in the region of the active disposal point in 1986 (50% of the images) than in 1985 (33% of the images). Overall, however, OSI values in the WLIS survey area have not changed. Moreover, RPD depths across the survey area have become shallower since 1985. This change appears to reflect bottom-water oxygen depletion. Near-bottom hypoxia was prevalent throughout much of the Sound in August 1986 (this is discussed further below).

This is the second REMOTS® survey at the WLIS disposal site since August 1985. The previous survey was conducted in October 1985, one month after Hurricane Gloria. This post-storm survey was concentrated on, and around, the three disposal mounds. The post-storm survey indicated that massive sediment transport or erosion of existing mounds did <u>not</u> occur. However, many stations experienced surface erosion which was deep enough to strip-off the aerated surface and expose reduced sediment to the water column. This phenomenon caused a major downward shift in Organism-Sediment Index Values. Table 4-1 compares the WLIS data collected during the present survey with data collected in the October 1985 post-storm survey. There is no difference in mean RPD depths for the WLIS stations, but OSI values in the present survey are significantly higher than those measured after the hurricane. This pattern indicates that the infaunal successional stages of the survey area have improved since October 1985. Table 4-1 also compares the WLIS Reference station, as measured in this survey, with the data collected in October 1985. Notably, mean RPD depths were shallower and OSI values were lower at WLIS Reference station in 1986 than in the disposal area after the storm.

The highly "stressed" conditions that presently exist at the WLIS Reference station are not readily explained. Near-surface reduced sediment patches were evident in all the References images; this feature suggests disturbance of the bottom (e.g., predator foraging or trawling activity). It is known, also, that severe bottom water hypoxia was widespread throughout western Long Island Sound at the time of the survey. In August 1986, a REMOTS® survey was conducted in Long Island Sound from New Haven, Connecticut to the Throgs Neck Bridge (SAIC, 1987). This survey, funded by EPA Region I, was conducted to characterize the dissolved oxygen conditions within 1 cm of the sediment surface over the entire area. A YSI digital oxygen meter and the YSI probe were mounted on the REMOTS® camera such that the probe membrane was 1 cm above the sediment-water interface. Five replicate images and dissolved oxygen measurements were made at each of 45 stations. One of these stations was located near Station 4-A of this survey (40°59.33N and 73°29.503W). The five replicate dissolved oxygen values were: 1.88, 1.90, 2.40, 1.84, and 1.80 mg/l. These values fall well below the Interstate Sanitation Commission's water quality standard of 5 mg/l. Similarly low values were found in deep water (generally > 15 meters) over the entire surveyed area (from Throgs Neck to New Haven). This hypoxic event was certainly a major contributing factor to the stressed benthic conditions observed at the WLIS survey area in 1986. This event does not explain why the WLIS Reference station was disturbed relative to the WLIS disposal region (both areas lie below a depth of 15 meters). However, it is apparent that the most severe ecosystem stress affecting the western Long Island Sound benthic environment is not directly related to disposal activities but to Sound-wide bottom hypoxia. Since the initiation of REMOTS® monitoring at the WLIS disposal site (1984), shallow RPD depths have been observed. This suggests persistent or recurrent hypoxia in the western Sound in recent years. Accurate spatial and temporal mapping of this event and research into the possible causes will become an active area of investigation over the next decade. It will be critical to incorporate the findings of this research into the long-term assessment of the impacts of dredged material disposal in Long Island Sound.

4.3 Sediment Characteristics

Sediment chemical analyses were previously conducted at the WLIS-A disposal mound during June 1984 (SAIC, 1985) and August and October 1985 (SAIC, 1986b). The October sampling and analysis was done to determine the effects of Hurricane Gloria. The Reference station was previously sampled during June 1984 and August 1985.

Comparison of the chemical concentrations measured in the Top core sections with those measured in the Bottom sections revealed that certain elements did exhibit higher concentrations in the Top core sections. For the samples from the WLIS-A and the Reference stations, lead, copper, nickel, and oil and grease were significantly higher ($p<0.05$) in the Top core sections. In addition, chromium was also significantly higher ($p<0.05$) in the Top sections at the Reference station. The reason for the elevated concentrations of those particular elements is not readily discernible at the present time. More intense sampling would be needed to accurately determine the actual relationships of the metal concentrations in the sediment.

When the sediment chemistry from previous samplings at the Reference station are compared to the results of the present sampling there (Table 3-1), the following can be concluded. The concentrations of most parameters measured in the present study are similar to those previously measured at this station. Exceptions to this were mercury and PCB's which showed significantly higher concentrations in the present survey and the Chemical Oxygen Demand which was lower.

At the WLIS-A mound the measured concentrations reported in Table 3-1 are again generally very similar to what has been previously reported (SAIC, 1985, 1986b). However, the concentrations of mercury, lead, chemical oxygen demand, and PCBs are significantly higher than the previously reported values.

Other studies have reported the concentrations of metals and PCBs in Long Island Sound sediments (Table 4-2). Benninger et al. (1979) measured the concentrations of lead, zinc, and copper in a sediment core collected in Central Long Island Sound. The zinc concentrations that they found ranged from 106-190 ppm in the top 10 cm of the sediment core. These values are very similar to the concentrations at both stations in the present study. The copper concentrations reported by Benninger et al. (1979) ranged from 44-96 ppm, again similar to the results reported here. Lead concentrations were 30-52 ppm. These levels are similar to the Reference site concentrations but lower than the levels reported at the WLIS-A mound (Table 3-1). Similar levels were also reported by Greig et al. (1977) in the area of the Western Long Island Sound Disposal Site. Therefore, the lead concentrations on the WLIS-A disposal mound are somewhat elevated over those of other sediments in the vicinity.

Greig et al. (1977) also measured the concentrations of nickel, chromium, mercury, and cadmium (Table 4-2). They measured nickel concentrations between 22.0 and 22.6 ppm in the vicinity of the disposal site. These are similar to the values measured for both sites of the present study. The chromium concentrations that Greig et al. (1977) reported were 159-164 ppm which were higher than the levels measured at both the WLIS-A and Reference stations in this study. The mercury concentrations that they reported were 0.5-0.6 ppm. These levels are similar to those from the present study and previous studies at the Western Long Island Disposal Site (SAIC, 1985). Cadmium levels were below the analytical detection limits of the Greig et al. (1977) study.

Munns et al. (in preparation) reported cadmium concentrations in sediment from the Reference station of the Central Long Island Sound (CLIS) Disposal Site to be near 0.3 ppm. This is considerably lower than the levels reported in the present study. The iron concentrations were similar in both studies. Munns et al. (in preparation) also measured PCB concentrations. They reported levels ranging from 0.03-0.05 ppm in Reference sediments. In the present study the concentrations were 0.09 at the Reference site and considerably higher (0.50) on the WLIS mound "A".

4.4 Benthic Community

The uniform, fine-grained, soft sediments at the WLIS Reference station limits the number of species present. The _Nucula_-_Nephtys_ assemblage present there is comprised predominately of deposit-feeders. Conversely, the heterogeneity of sediment types (sand mixed with mud) in the disposal site allows different lifeforms and feeding types to become established. Species requiring solid surfaces for attachment (e.g., the polychaete _Sabellaria_, the gastropod _Crepidula_), tube dwellers or burrowers requiring silty sand or sandy substrate (e.g., the polychaetes _Pherusa_, _Pectinaria_, _Euclymene_, _Ampharete_; the amphipod _Leptocheirus_; the bivalves _Ensis_, _Tellina_),and deposit feeders (e.g., _Euclymene_, _Ampharete_, _Mediomastus_ and _Tharyx_ _acutus_) all occur at the WLIS-A station. In large part, this sediment type difference accounts for the greater species richness in the survey area relative to the Reference station.

The disposal mound station is dominated by surface-dwelling deposit feeders (_Mediomastus_ makes up 52% of all individuals counted). This corresponds to the REMOTS® analysis which indicates that the station closest to the center of mound

"A" (5-E), exhibits a Stage I successional status. The benthic results also indicate that some recolonization by deeper-dwelling deposit feeders (Stage III infauna) has occurred in this area. The maldanid, Euclymene zonalis, is the second most abundant polychaete in the samples, and small numbers of Nephtys, and the bivalves Nucula and Yoldia are present. The REMOTS® stations immediately adjacent to station 5-E to the north, east, and west reveal Stage III infauna. It is apparent from these data that benthic recolonization of disposal point "A" is occurring, but at a reduced rate relative to other Long Island Sound disposal sites. This reduced rate of recovery does not appear to be due to any character of the dredged material disposal operations, but rather to the widespread ecosystem stresses (i.e., hypoxia) which are occurring in the western Sound.

The benthic community results from the Reference station support this conclusion. In terms of the types of species present, the samples revealed a Nucula-Nephtys deposit-feeding community characteristic of silt-clay bottoms of central Long Island Sound. However, few mature individuals and lower densities of species were found at this station relative to the CLIS Reference station. The REMOTS® analysis detected Stage III seres in only 30% of the Reference images. This area, and western Long Island Sound in general, is apparently experiencing severe ecological stress.

4.5 Body Burden Analysis

Lead was the only element that showed significantly ($p<0.05$) higher concentrations in Nephtys collected from the WLIS mound "A" compared to levels at the Reference station. The mean lead concentrations were 3.7 ppm at WLIS-A and 2.9 ppm dry weight at the Reference station (Table 3-6). These concentrations from both sites are very similar to the levels that Munns et al. (in preparation) reported for the reference station at the Central Long Island Sound Disposal Site (Table 4-3). On dredged material, Munns et al. (in preparation) measured lead concentrations in Nephtys of about 4.7-8.9 ppm. Because the Nephtys analyzed in the present study were purged of gut contents and those analyzed by Munns et al. (in preparation) were not purged, the higher levels for some elements in that study may be due to sediment in the gut of the organisms.

The concentrations of zinc and cadmium were significantly ($p<0.05$) higher in Nephtys collected from the Reference location when compared to organisms from WLIS-A in the present study. In both cases, however, the levels were similar to or lower than what Munns et al. (in preparation) found at the Central Long Island Sound Reference station (Table 4-3). The cadmium concentrations found in the present study are all lower

(0.25-0.48 ppm) than the concentrations reported by Munns et al. (in preparation).

Similar results were also observed for chromium and copper. Munns et al. (in preparation) reported that chromium concentrations in Nephtys collected away from dredged material ranged from 1-5 ppm dry weight. This is slightly higher than the range of concentrations (0.42-0.72 ppm) found in the present study (Table 4-3). For copper the range of concentrations reported here are 12-16 ppm compared to about 22-33 ppm at the Central Long Island Sound Reference station (Munns et al. in preparation).

The iron concentrations showed a similar trend. The concentrations reported for the present study were between 490 and 570 ppm dry weight whereas those measured by Munns et al. (in preparation) were all between 400 and 1100 ppm.

The PCB concentrations reported here (Table 3-8) for Nephtys were below the analytical detection limits for all but two samples. In both cases the measured concentrations were Aroclor 1254 in organisms collected from the Reference station. The levels measured were 420 and 620 ppb dry weight. These levels are slightly higher than those measured by Munns et al. (in preparation) in Nephtys from their Reference station at CLIS (186-375 ppb).

It is somewhat surprising to see measurable PCB concentrations in the Reference organisms and not in those collected from the WLIS-A station. This would not be expected because the sediment PCB results showed a level of 90 ppb at the Reference station and 500 ppb at WLIS-A (Table 3-1). In all cases, the measured wet weight concentrations for mercury (Table 3-7) and PCBs (Table 3-8) are well below the FDA Alert Levels (0.2 ppm for mercury, 2 ppm for PCB's).

5.0 CONCLUSIONS

The results of the analysis of the bathymetric data collected at the WLIS Disposal Site indicates an accumulation of sediment (estimated from bathymetry surveys to be approximately 35,700 m^3) in the vicinity of the disposal buoy. Comparison of the contoured bathymetric charts from the October 1985 and the August 1986 surveys reveals a decrease in depth at the buoy location and on the west flank of mound "C" and the northeast flank of mound "A". Because of the buoy's position between the two mounds, the deposited dredged material will tend to create a single, wide flat mound. This may, in fact, aid in stabilizing the dredged material. The peaks of dredged material mounds are usually the site of any initial erosion that may occur.

The REMOTS® survey showed that recently deposited dredged material was evident in the area of disposal point "C", supporting the results of the bathymetric survey. Much of this newly deposited dredged material consists of coarse-grained sediments (fine to medium sands). This material may extend somewhat beyond the survey area to the east and northeast. However, given that the survey area is approximately 1600 meters west and 900 meters south of the Disposal Site boundaries, it is highly unlikely that this material extends out of the disposal site. Lower contrast dredged material layers were evident in the western portion of the survey area apparently representing material deposited a number of years ago. Apparent relict dredged material is observed in some replicates from the WLIS Reference station. This material is clearly relict (deposited more than just a few years ago) based on its extremely low reflectance and discontinuous layering. Relict dredged material has been observed at this station since the initiation of REMOTS surveys in 1984. The reference station is located close to an historically-used disposal site (Eatons Neck). There is no evidence that recent disposal activities have occurred at this location.

Although limited benthic recolonization of the survey area had occurred since the August 1985 survey, the area continued to exhibit a "stressed" biological community. The highly disturbed WLIS Reference community indicated that this stress was not directly related to disposal activities, but reflected a regional ecosystem disturbance factor, i.e., bottom hypoxia.

Statistical analyses of the chemical data collected for the sediment at WLIS indicated that the concentrations of lead, nickel, copper, and oil and grease were elevated in the WLIS-A sediment compared to the levels at the Reference station. The concentrations of nickel and copper are, however, only slightly elevated in the dredged material and are within the range of concentrations reported by other investigators for central and western Long Island Sound. The lead concentrations at WLIS-A are, however, elevated compared to what other investigators have found. These same four elements exhibited elevated concentrations in the top 2 cm of the sediment cores when compared to the remaining 2-10 cm for both the disposal mound and Reference station. The reason for only these elements to be elevated is unknown, but more sampling would be required to determine the actual chemical and physical processes occurring in the sediment. In addition to the above elements, the PCB concentration appeared to be high in the WLIS-A sample.

For the concentrations of metals in the body tissue of Nephtys, only the concentration of lead was significantly higher in Nephtys collected from WLIS-A compared to levels in organisms collected from the Reference station. This is consistent with significantly elevated levels of lead in the WLIS-A sediment. The concentrations of mercury were well below the FDA Alert Level.

In summary, the results of the present survey indicates that the management controls over dredged material disposal at WLIS, initiated by New England Division, Corps of Engineers, have been effective in minimizing the dispersion of dredged material and preventing any significant adverse environmental impacts. Distinct disposal mounds have been formed by disposal operations occurring at taut-moored buoys and appear to be stable with no evidence of erosion or significant transport of material. The "stressed" condition at the disposal site is not attributible to disposal operations but rather to conditions in Western Long Island Sound in general.

6.0 RECOMMENDATIONS

The DAMOS monitoring protocol for disposal sites in Long Island Sound depends on comparing disposal site conditions with an appropriate reference, i.e., a nearby area of seafloor which is not affected by the disposal events. The WLIS Reference station was clearly more stressed than the survey area. The reason for this may be low bottom water oxygen. However, it is not clear why the Reference station, located only 2 km east of the survey area, should have been more oxygen stressed. Future monitoring should include some near-bottom oxygen monitoring and an additional reference station should be located to document how widespread are the changes measured at the present one. This may not be possible for this area of the Sound because the study done for EPA Region I has shown that low oxygen water exists at depths of 50 feet or more throughout this area in August. While year-to-year variations may be present in bottom water oxygen, extended periods of low oxygen tensions in the range measured can seriously compromise the benthic habitat throughout the whole region. In short, a relatively undisturbed Reference site may not exist in the vicinity of the disposal site.

7.0 REFERENCES

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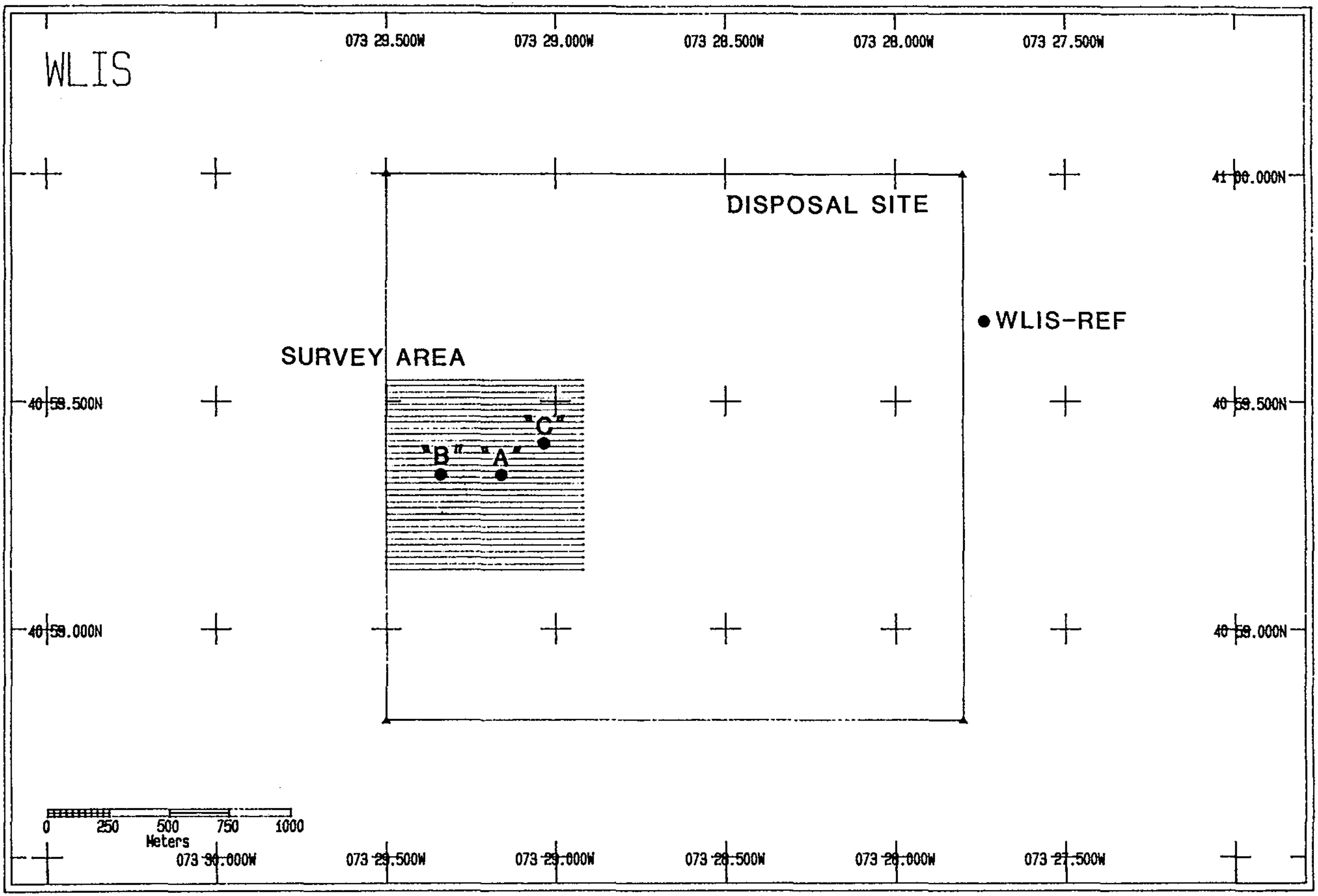


Figure 2-1. The Western Long Island Sound Disposal Site.

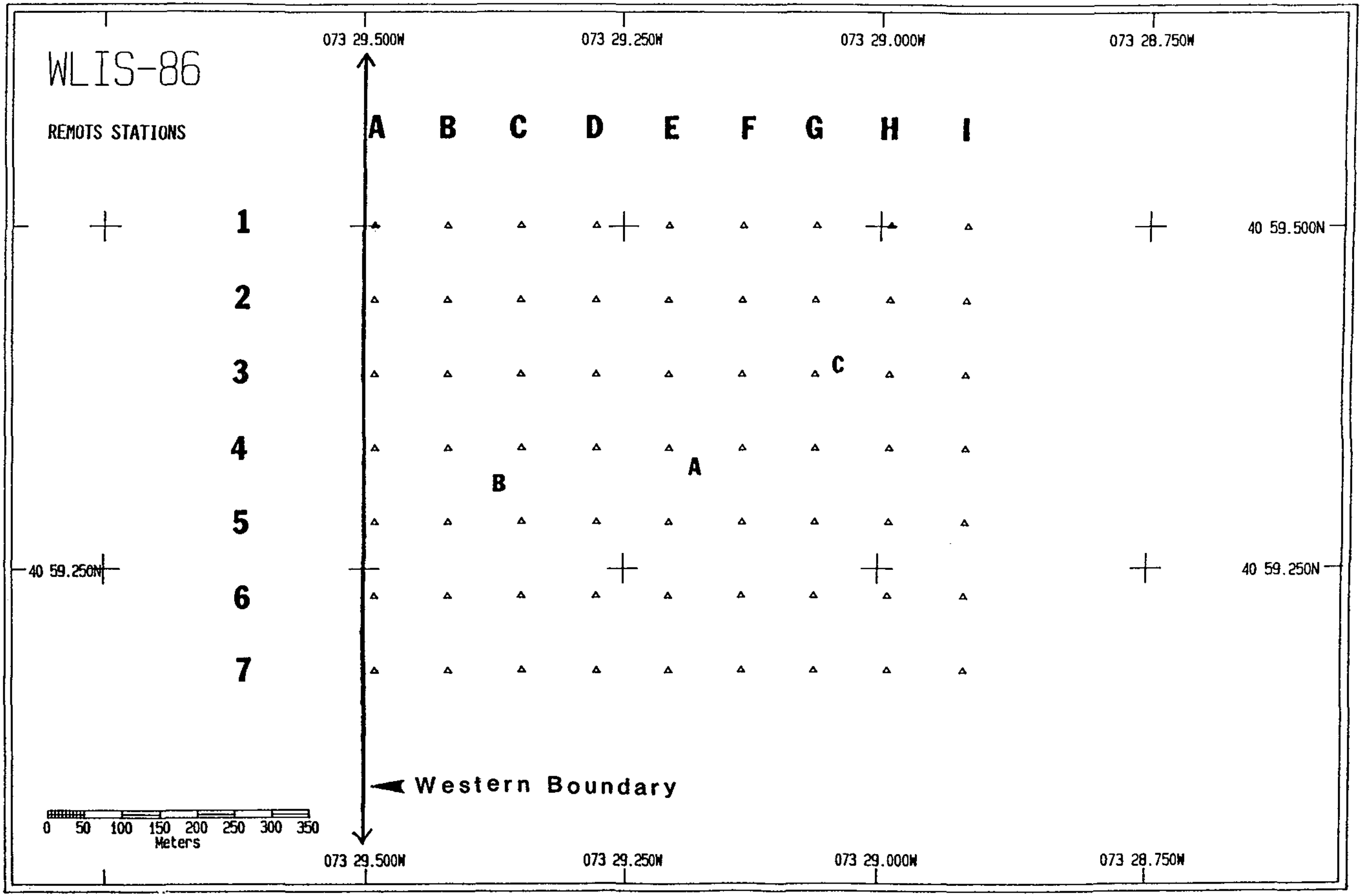


Figure 2-2. REMOTS stations occupied during the 1986 survey of the WLIS disposal area. Disposal points "A", "B", and "C" are indicated.

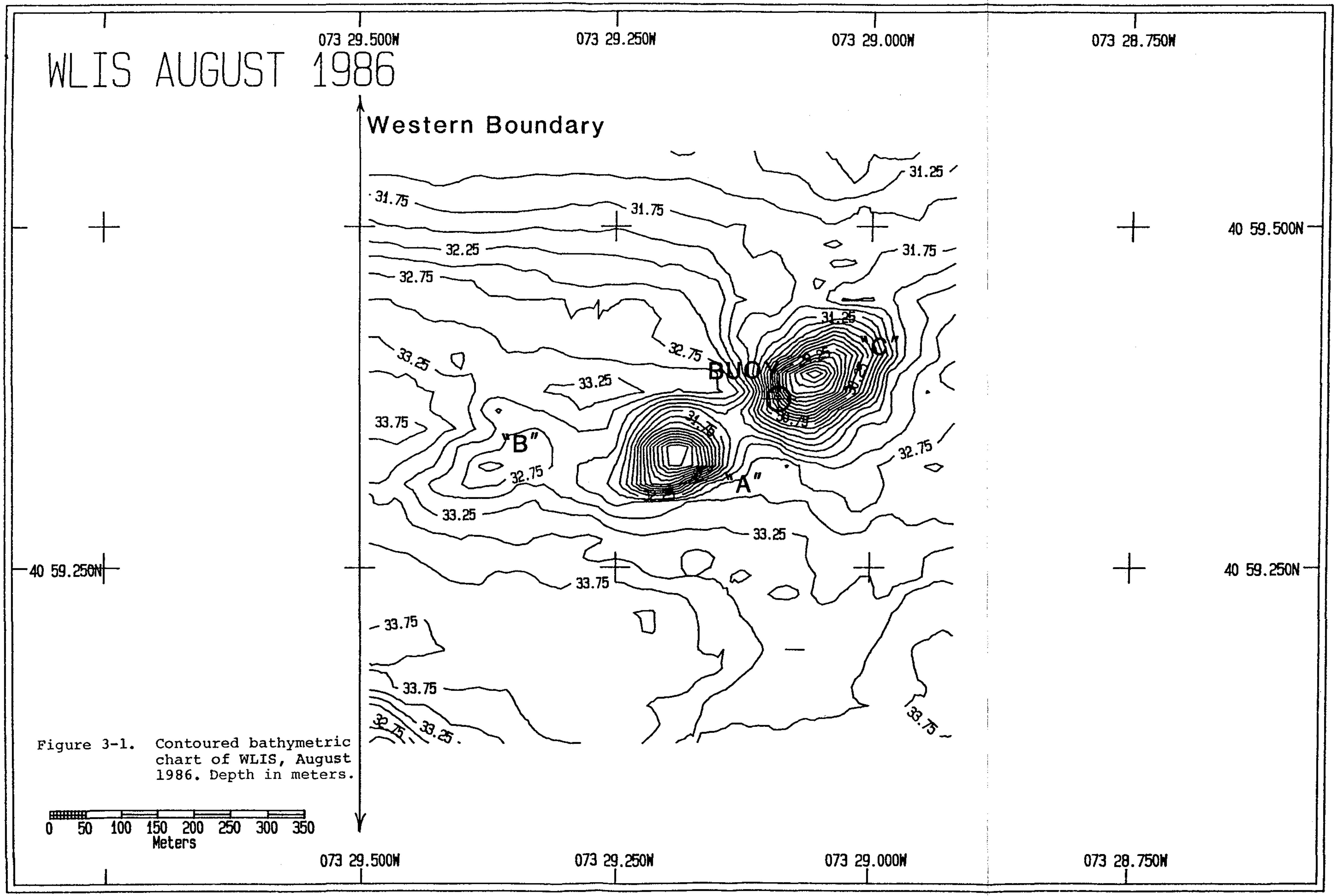


Figure 3-1. Contoured bathymetric chart of WLIS, August 1986. Depth in meters.

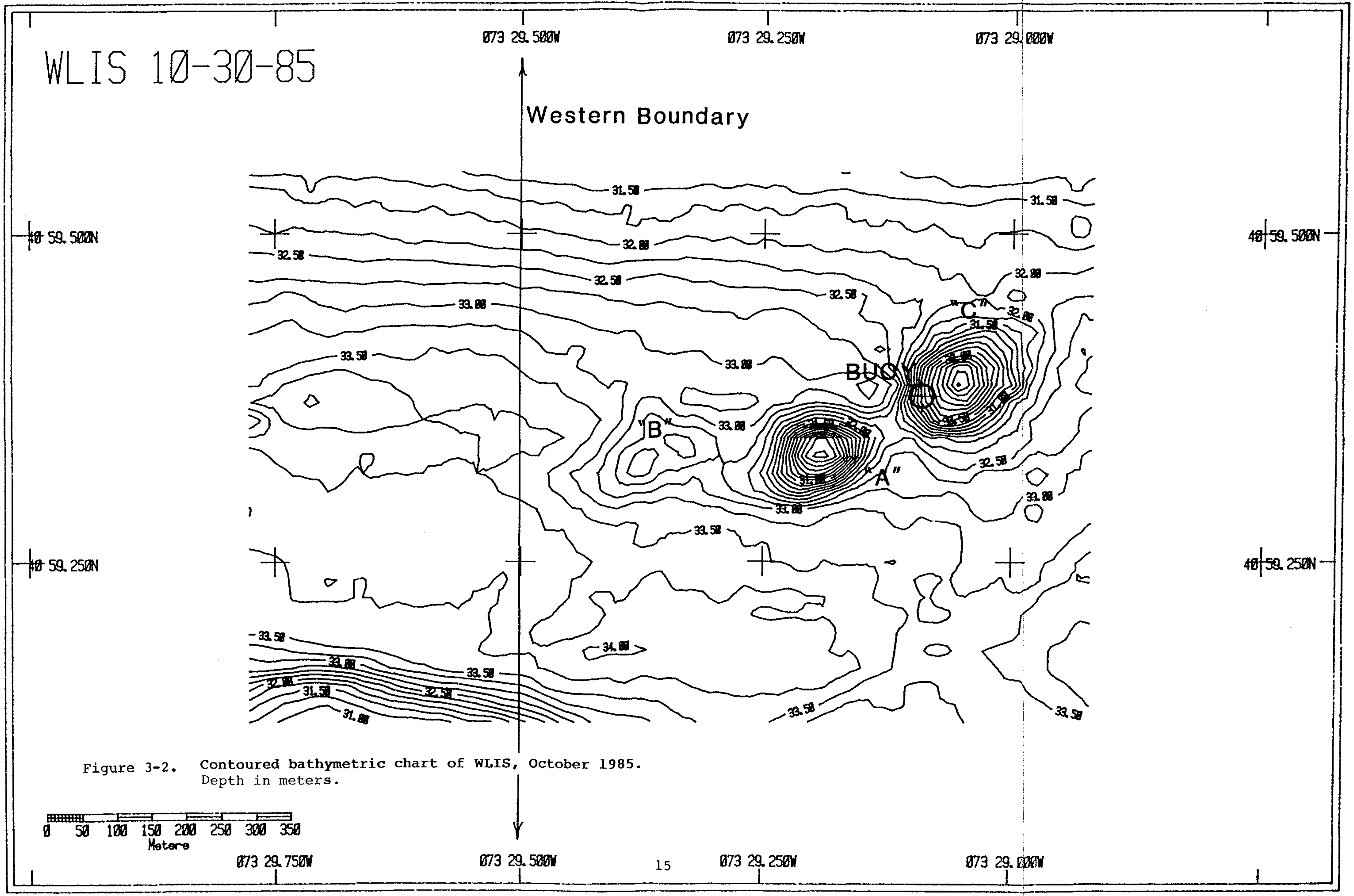


Figure 3-2. Contoured bathymetric chart of WLIS, October 1985. Depth in meters.

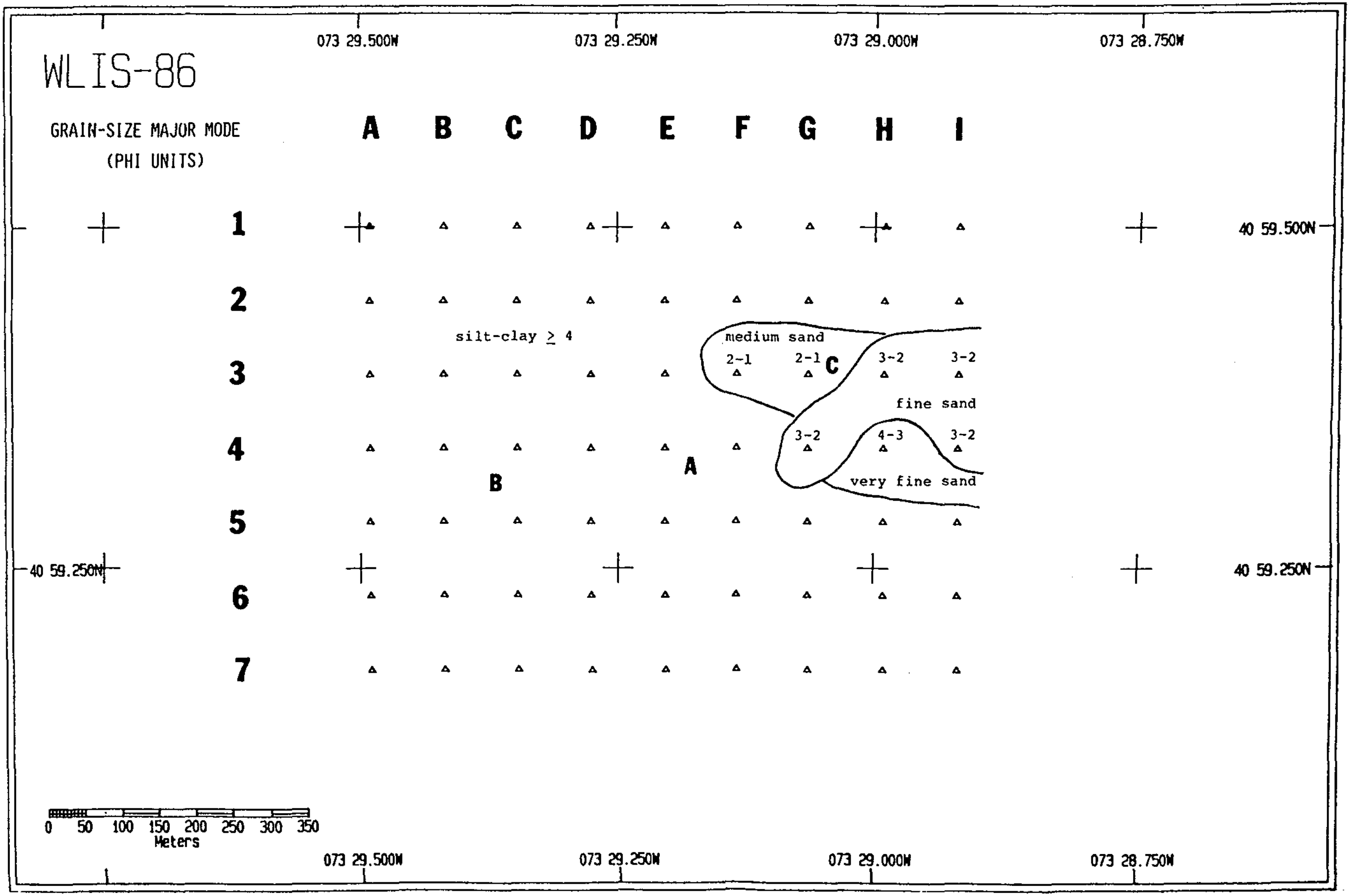


Figure 3-3. The distribution of grain-size major modes. All stations without values exhibited a major mode of ≥ 4 phi. The contours enclose areas dominated by sandy sediments.

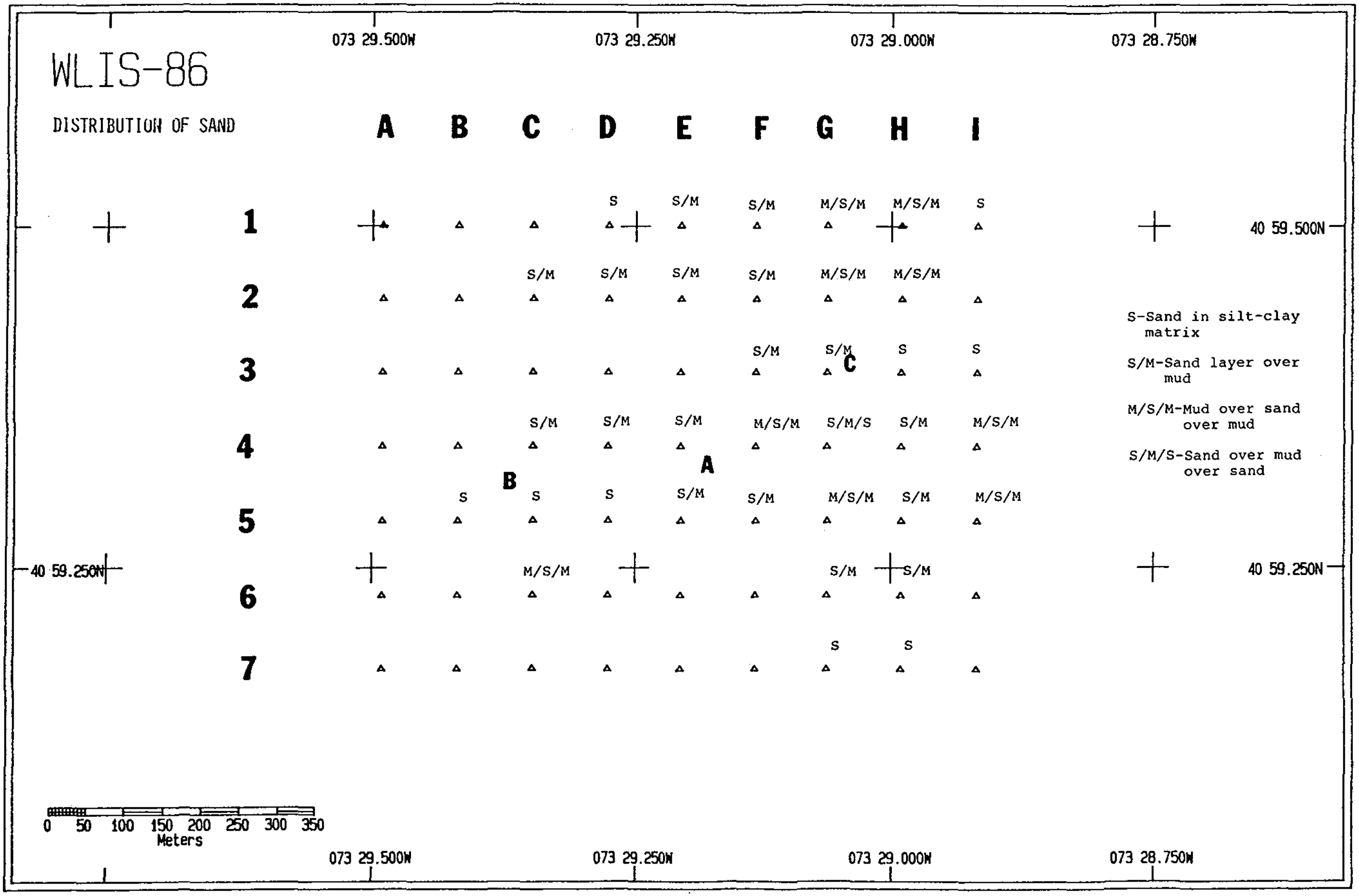


Figure 3-4. The distribution of sand and sand layers in the survey area.

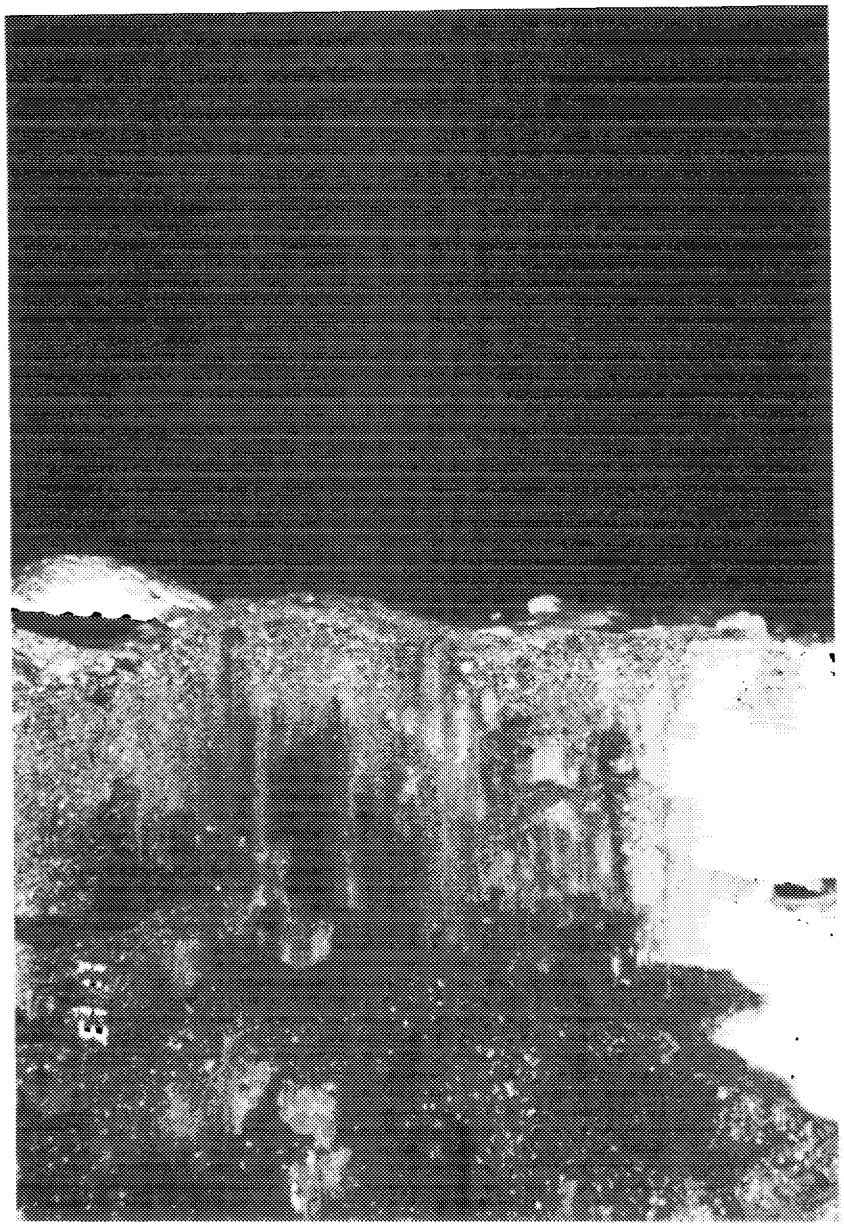


Figure 3-5. A REMOTS image from station 4-G showing both suface and subsurface sand layers. Also, note the caridean shrimp to the right at the interface. Scale: Actual width of frame = 15.2cm.

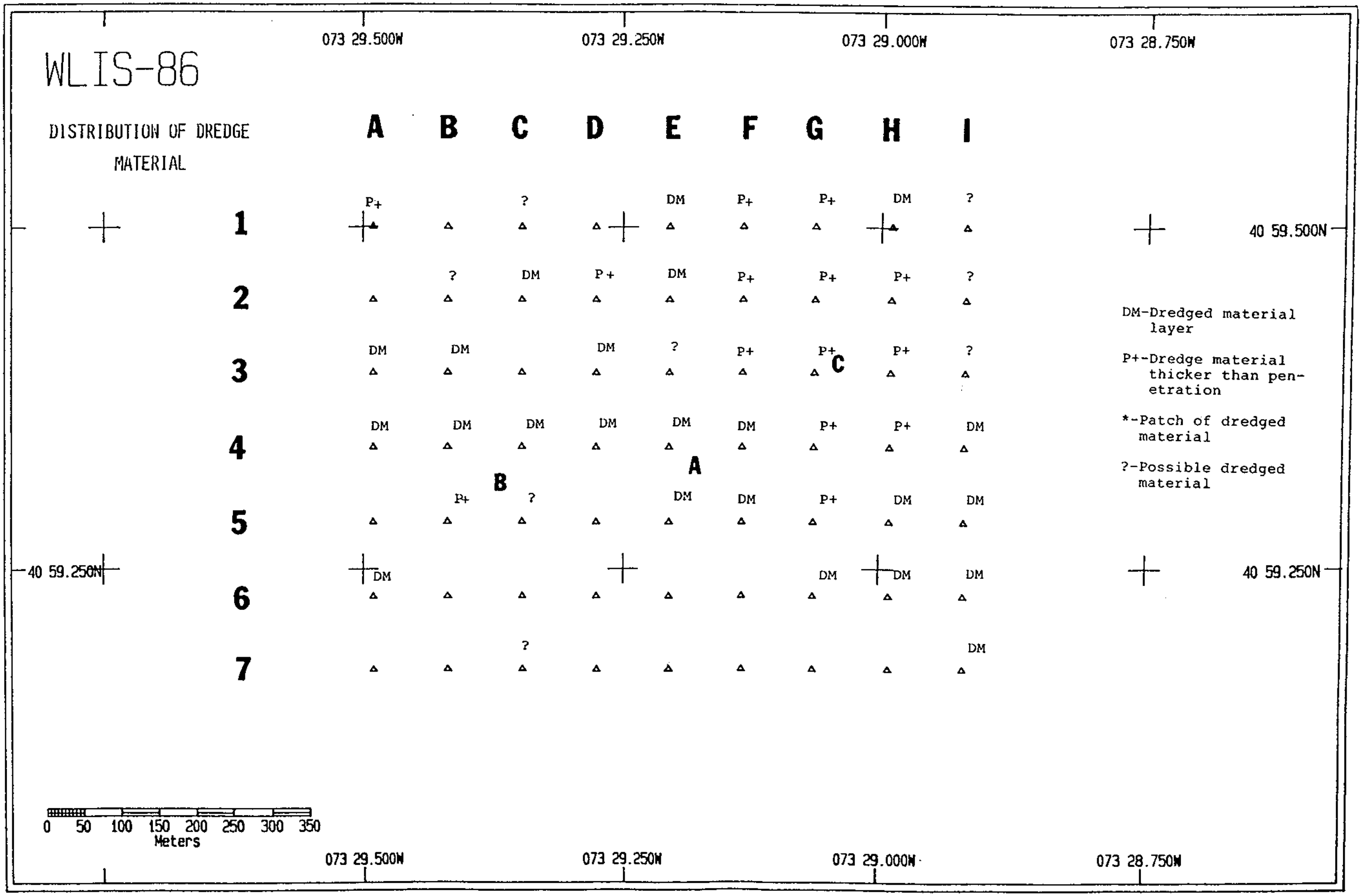


Figure 3-6. The distribution of dredged material in the WLIS survey area.

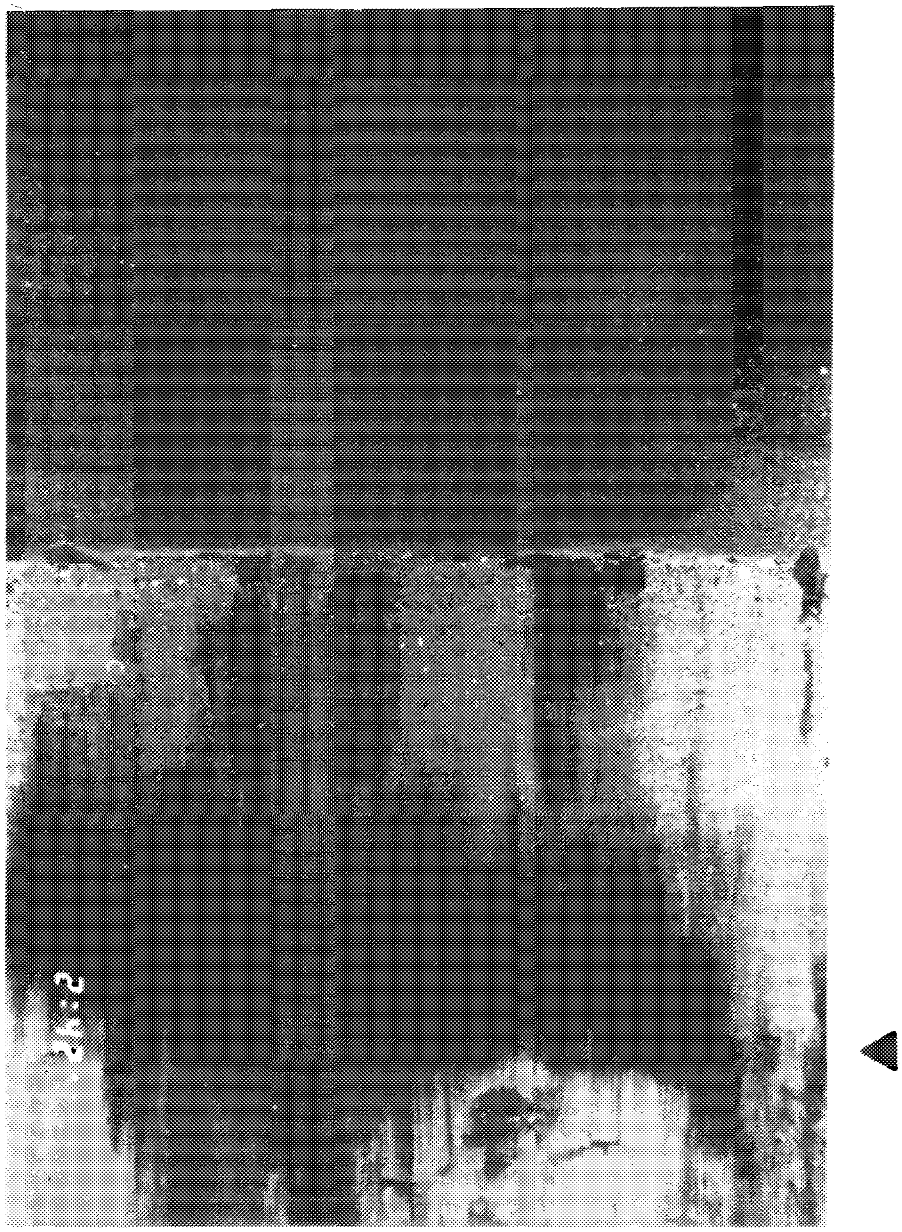


Figure 3-7. A REMOTS image from station 5-E showing a low-reflectance dredged material layer overlying a high-reflectance pre-disposal interface (arrow). Also note the patches of reduced (dark) sediment at the interface. Scale: Actual width of frame = 15.2cm.

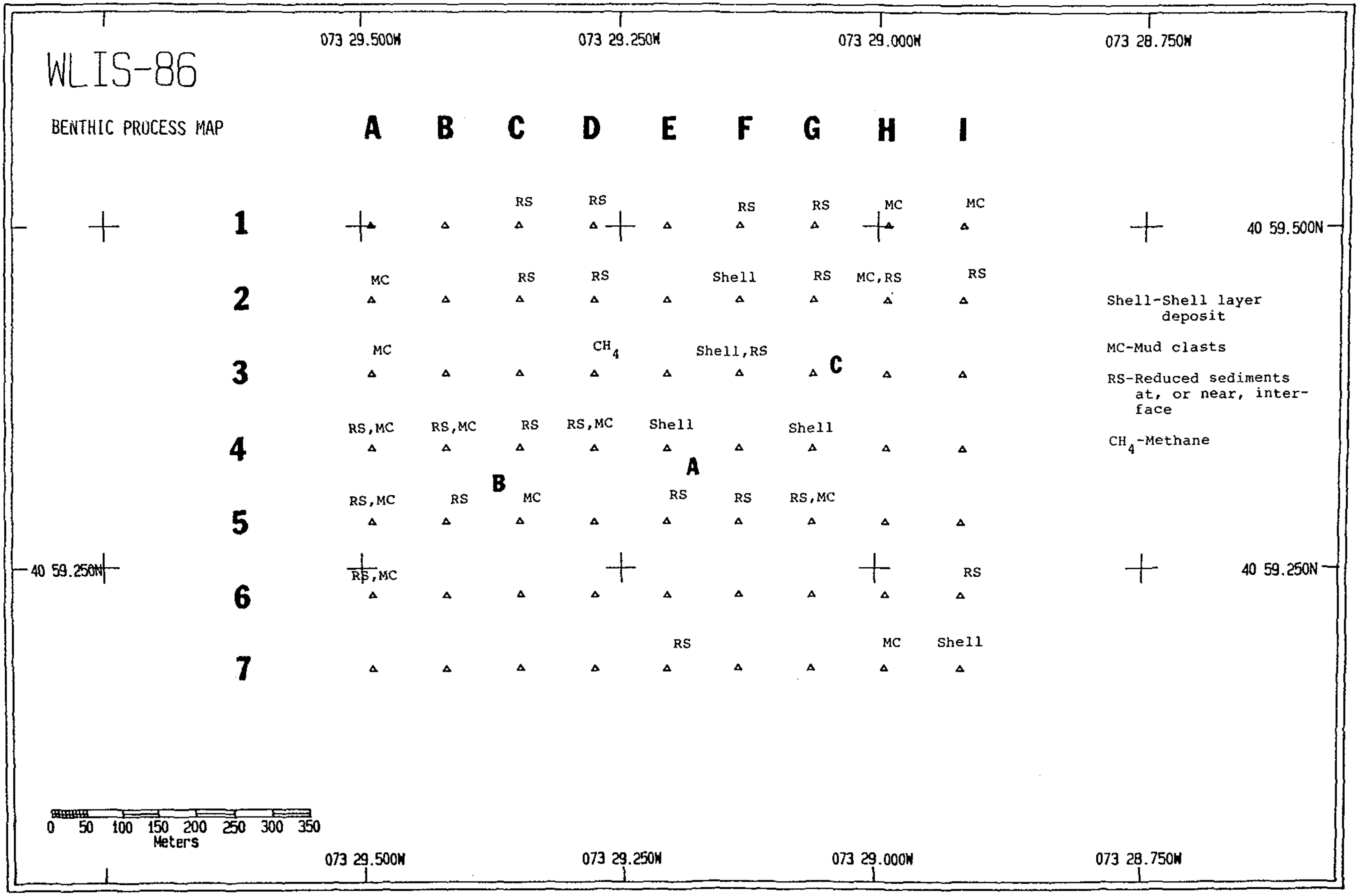


Figure 3-8. A benthic process map showing features indicative of bottom disturbances.

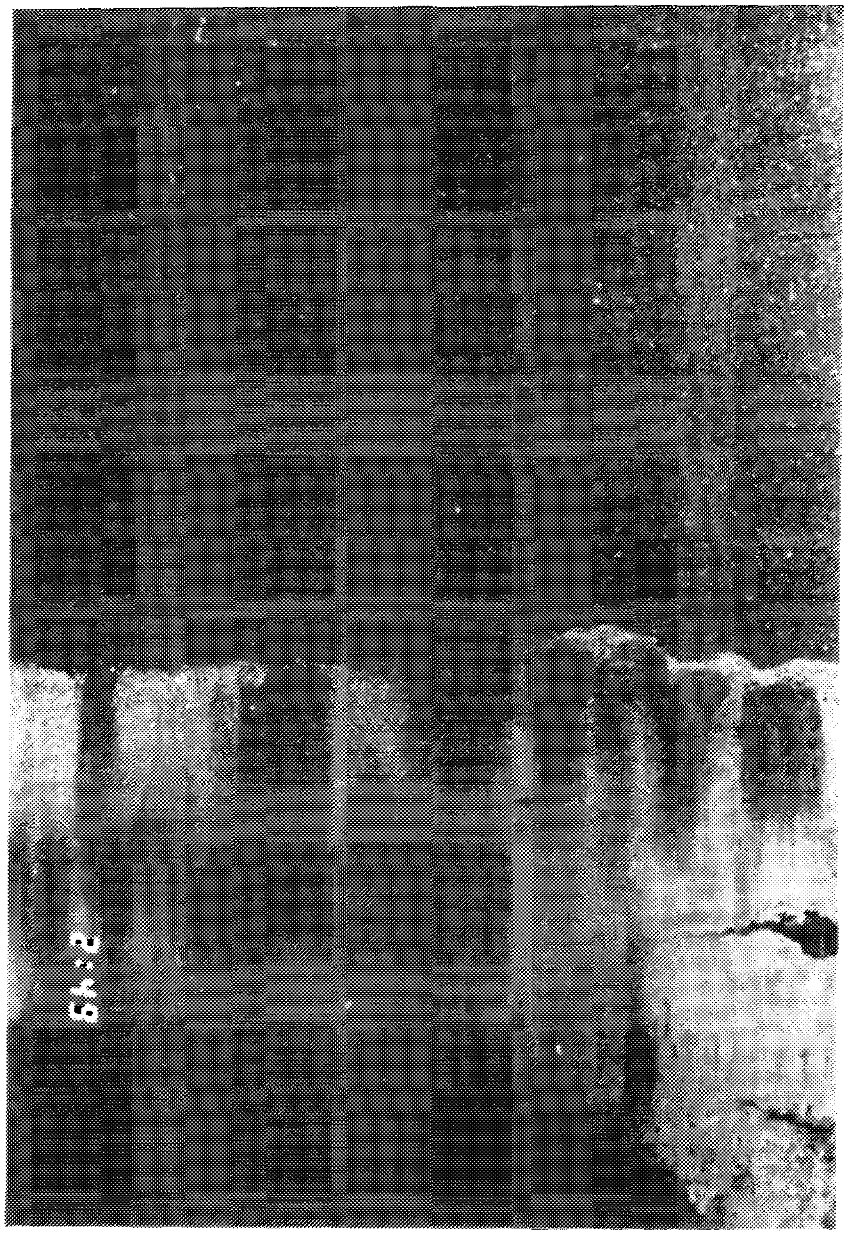


Figure 3-9. A REMOTS image from station 5-F showing reduced (dark) sediment patches at the interface. These features are indicative of recent bottom disturbance. Scale: Actual width of frame = 15.2cm.

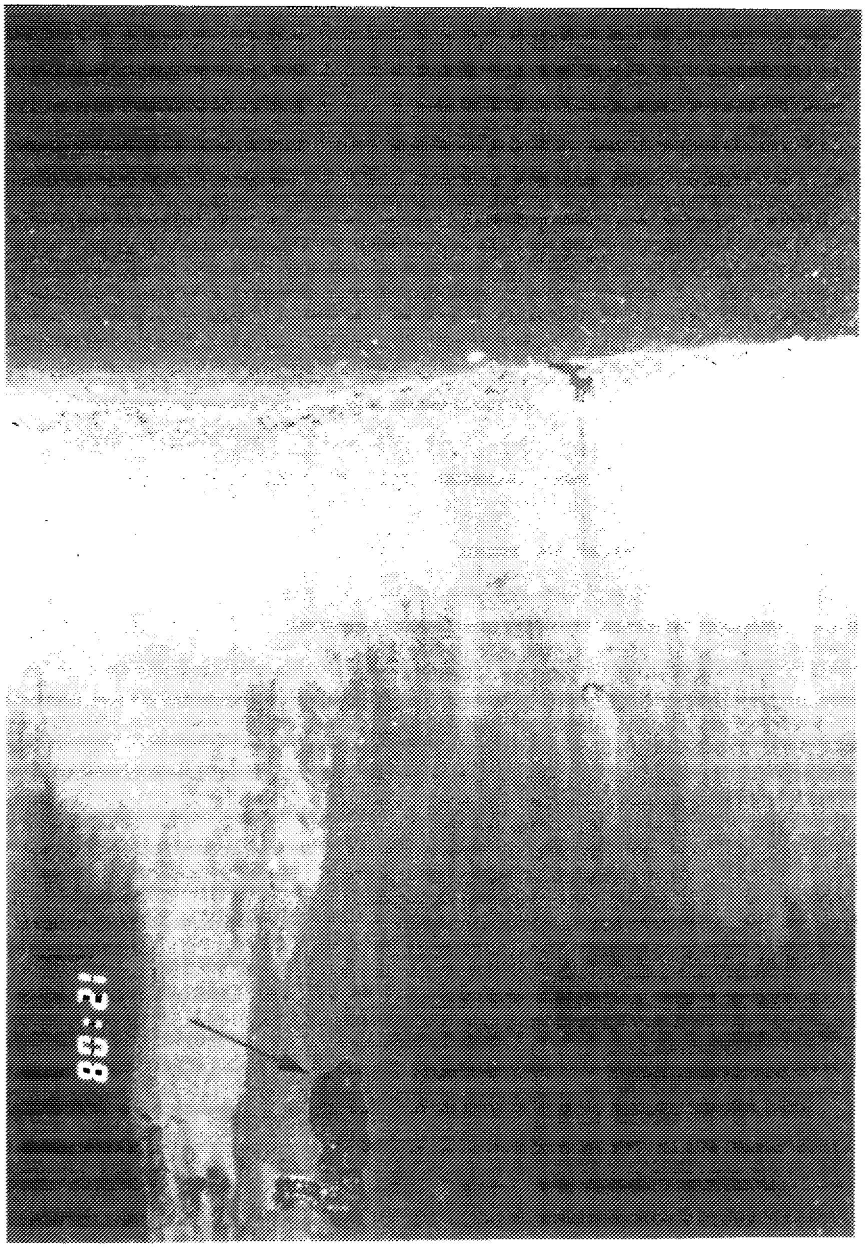
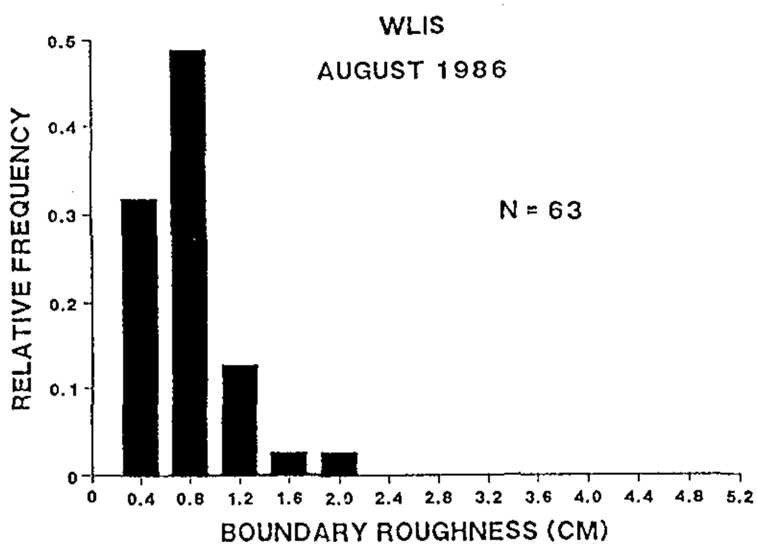


Figure 3-10. A REMOTS image from station 3-D showing a methane gas pocket at depth in sediment (arrow). Scale: Actual width of frame = 15.2cm.



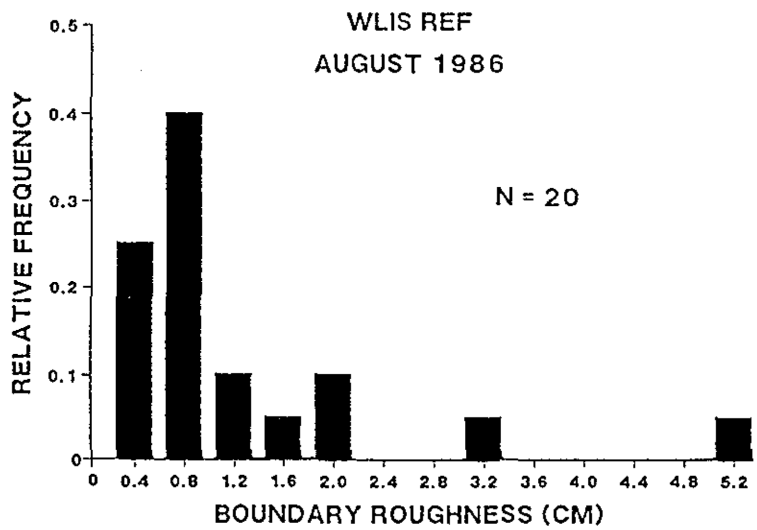
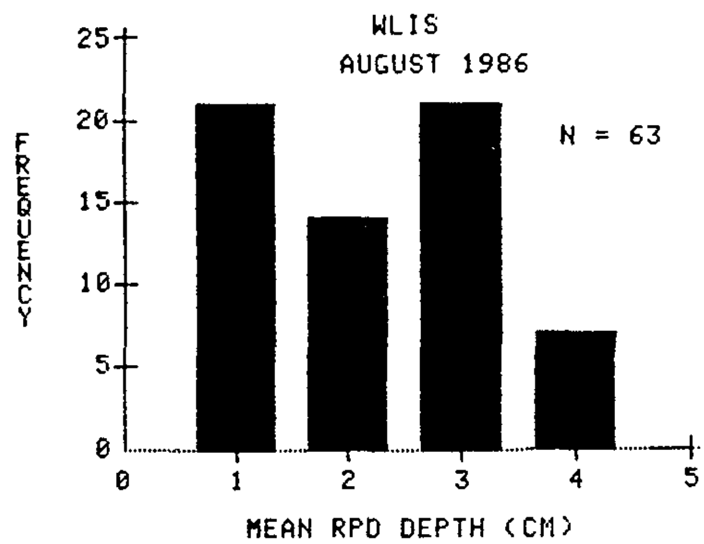


Figure 3-11. Frequency distributions of boundary roughness values at WLIS and WLIS reference.



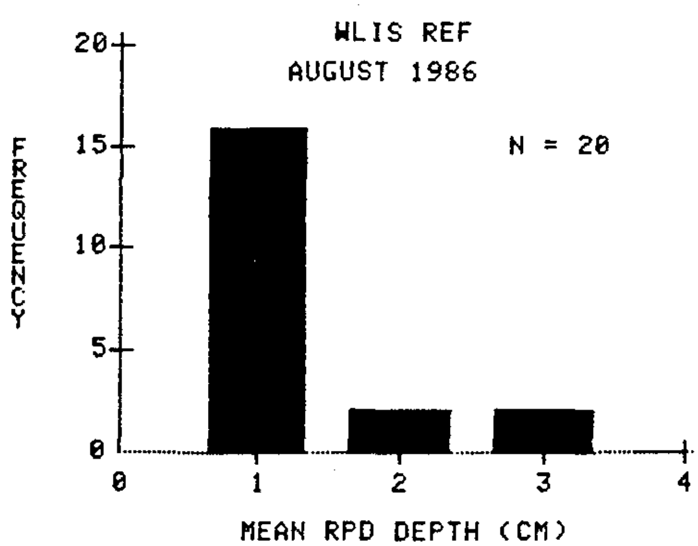


Figure 3-12. Frequency distributions of mean RPD depths at WLIS and WLIS reference.

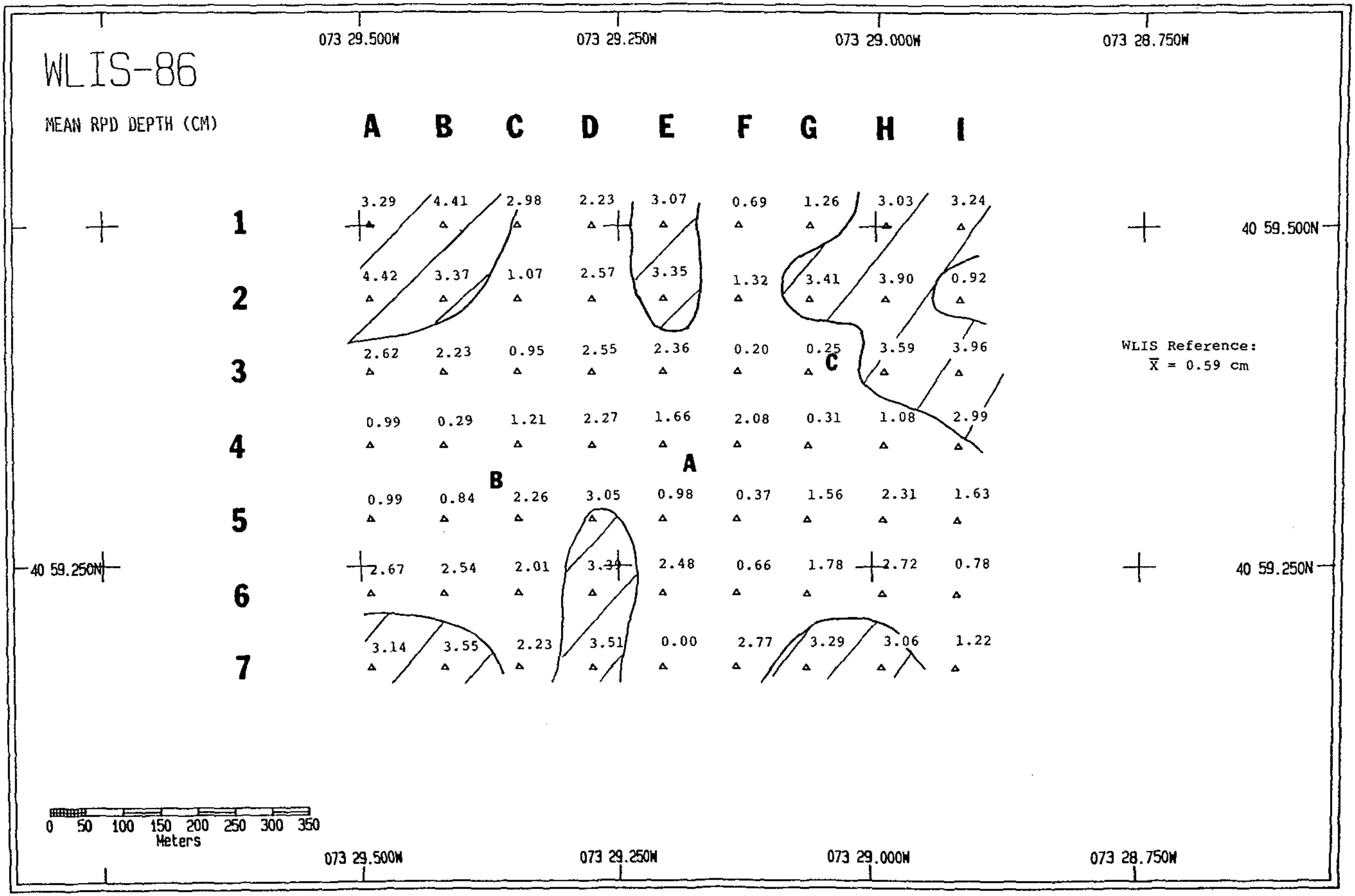


Figure 3-13. The distribution of RPD depths (cm). The hatched areas are regions where RPD depths are greater than 3.00 cm.

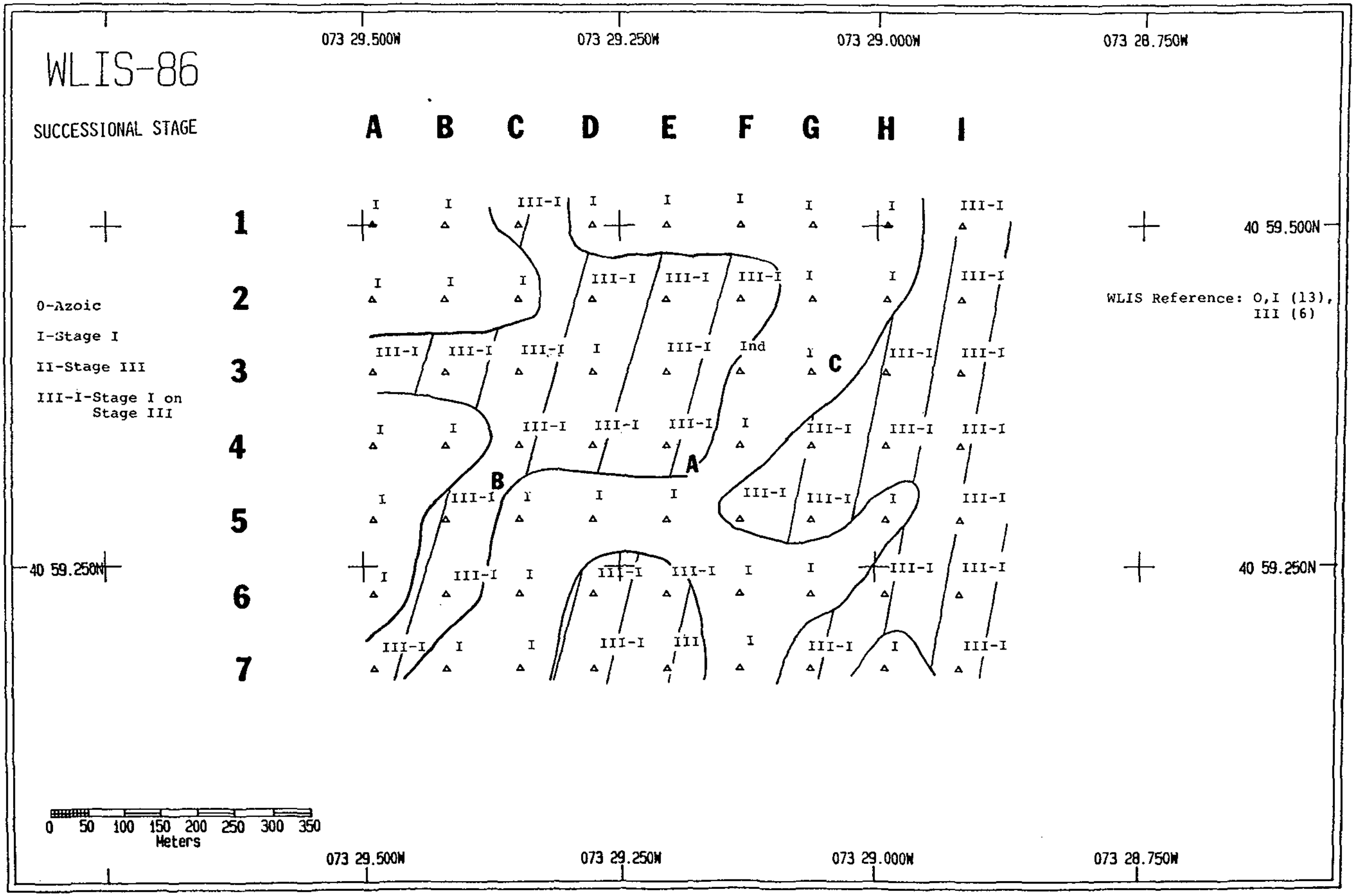
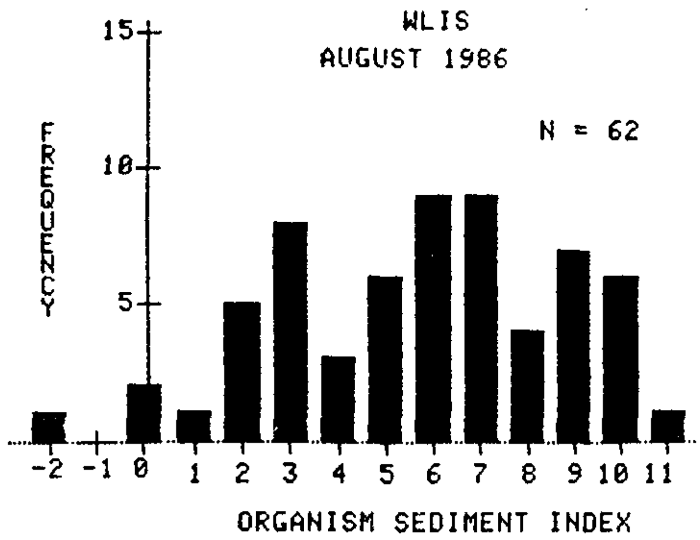


Figure 3-14. The distribution of infaunal successional stages. The hatched areas are those exhibiting Stage III seres. An "Ind" indicates that the successional stage was indeterminate.



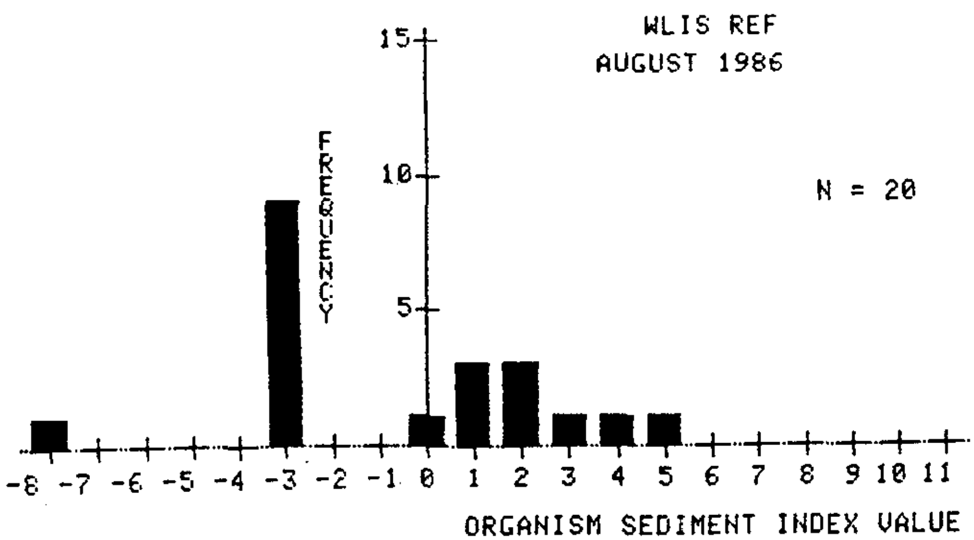


Figure 3-15. The frequency distribution and Organism-Sediment Index values at WLIS and WLIS reference.

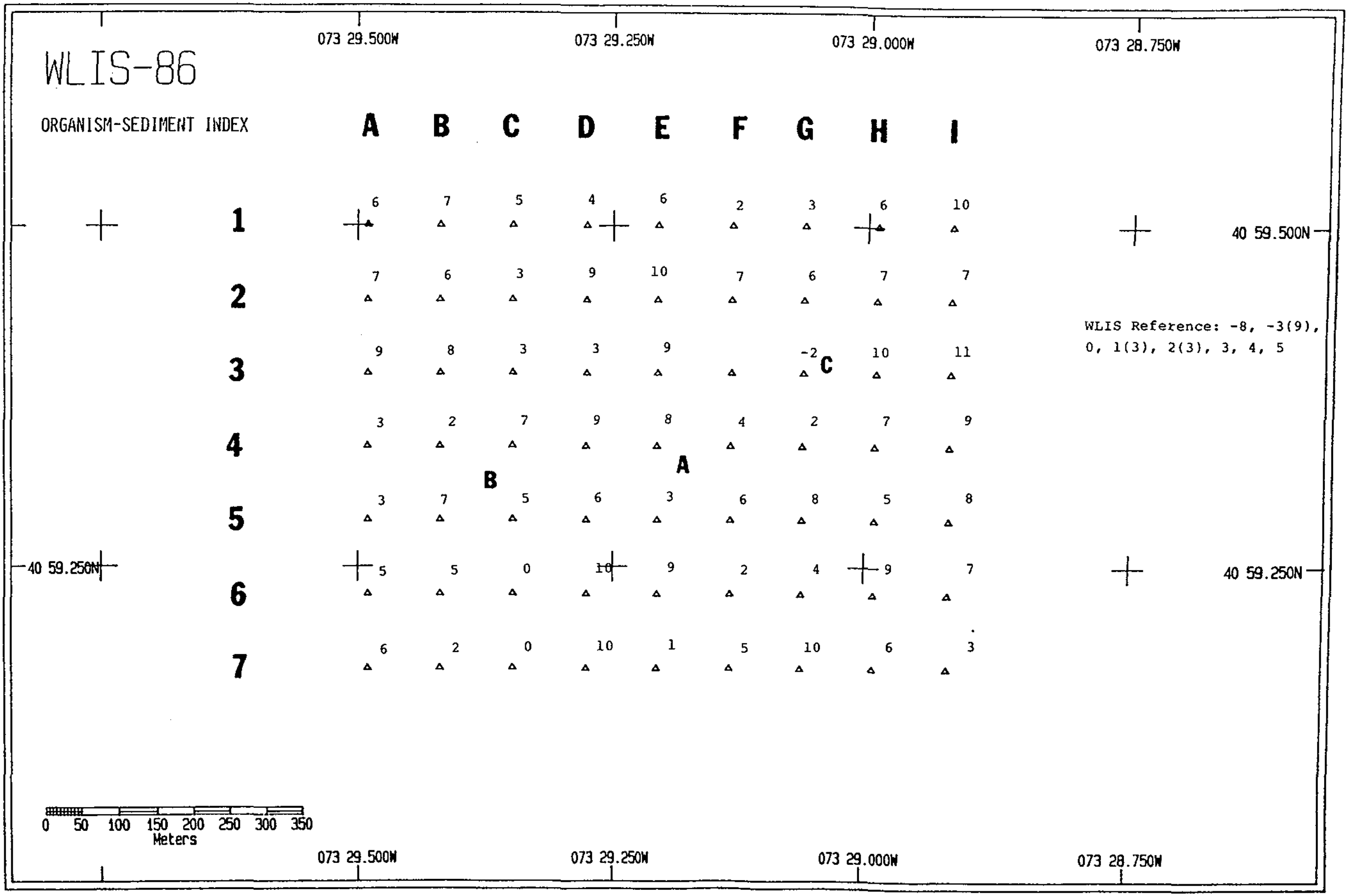


Figure 3-16. The distribution of Organism-Sediment Index values. An OSI could not be calculated for station 3-F, due to an indeterminate successional status.

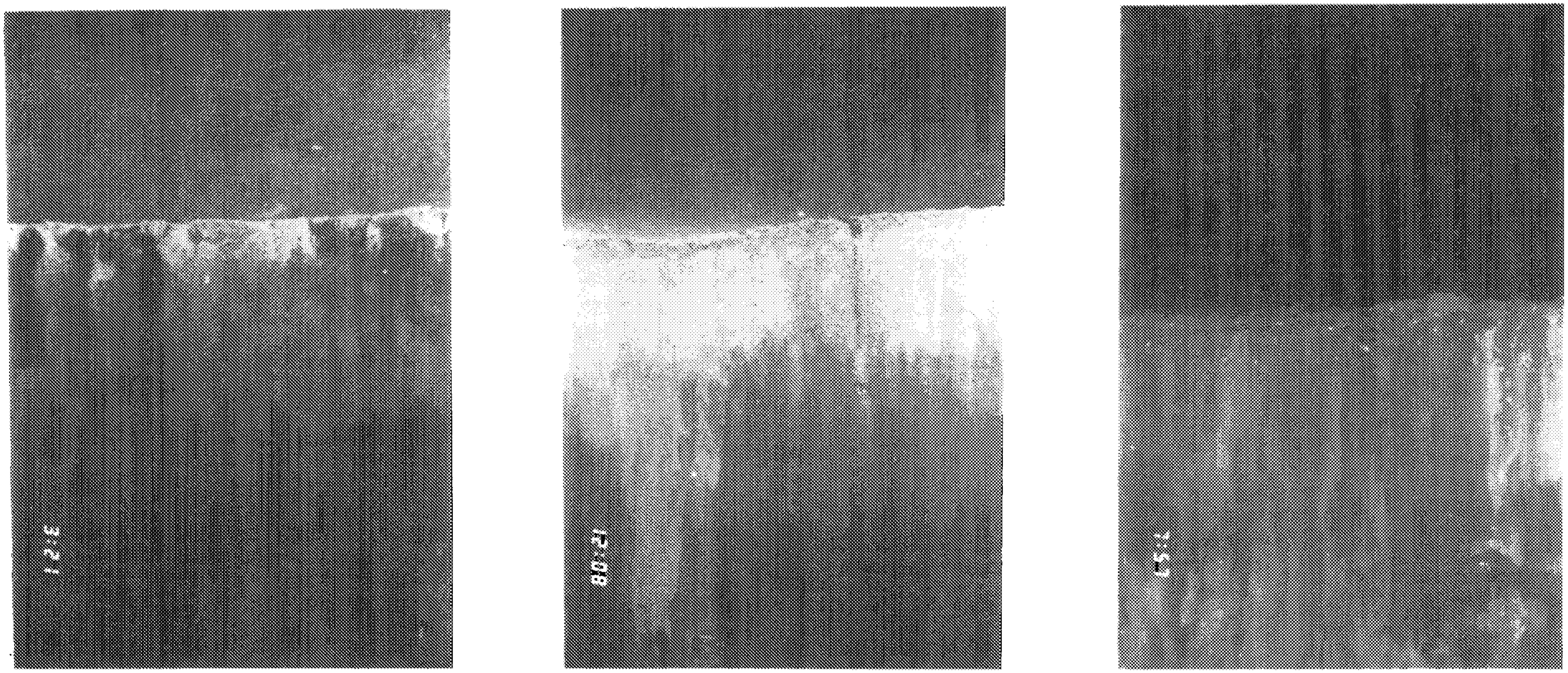


Figure 4-1. REMOTS images from station 6-H (left) showing recently deposited dredged material, and from station 3-D (middle) and WLIS Reference (right) showing relict dredged material layers. In each image, the bottom of the dredged material layer is coincident with the : in the time display. The layer at 6-H exhibits higher contrast with adjacent sediments and is intact relative to the relict dredged material layers (see text for further discussion,). Scale: width of frame = 15.2cm.

Table 2-1

Instrument Operating Conditions and Detection Limits for Metals Analyzed by Flame Atomic Absorption Spectrometry

Element	Wavelength (nm)	Lamp Current (mA)	Slit Width (mm)	Gas Oxidant/ Fuel	Flame Type	Minimum Detection Limit (ppm)	Sensitivity (ppm/0.0044 Abs)	Additional Comments
Cu	324.7	10	1.0	Air/C_2H_2	Oxidizing	0.04	0.1	D_2 correction
Zn	213.9	15	1.0	Air/C_2H_2	Oxidizing	0.015	0.002	D_2 correction

Table 2-2

Instrument Operating Conditions and Detection Limits for Metals Analyzed by Graphite Furnace Atomic Absorption Spectrophotometry

Element	Wave Length (nm)	Lamp Current (mA)	Slit Opening (mm)	Injection Volume (ul)	Gas	Furnace Conditions
As	193.7	18	1.0	20	Ar (3 sec, normal flow, 20)	Dry: 110°C, 30 sec Char: 1200°C, 30 sec Atomize: 2700°C, 8 sec
Cd	228.8	4	1.0	10	Ar (3 sec, normal flow, 20)	Dry: 110°C, 22 sec Char: 350°, 22 sec Atomize: 2100°C, 7 sec
Cr	357.9	14	1.0	20	Ar (3 sec, normal flow, 30)	Dry: 110°C, 22 sec Char: 1100°, 22 sec Atomize: 2700°C, 7 sec
Hg	254	–	–	–	–	–
Pb	283.3	10	1.0	20	Ar (3 sec, normal flow, 20)	Dry: 110°C, 22 sec Char: 750°C, 22 sec Atomize: 2300°C, 7 sec

Table 2-2
(continued)

Element	Minimum Detection Limit (ppb)	Absolute Detection Limit (picograms)	Sensitivity (ppb/ 0.0044 ABS)	Sensitivity (picograms/ 0.0044 ABS)	Additional Comments
As	2	40	5	100	D_2 correction
Cd	0.1	1	0.3	3	D_2 correction
Cr	0.5	10	0.7	14	D_2 correction
Hg	0.5[a]	500	---	---	Cold vapor analysis
Pb	0.5	10	1	20	D_2 correction

TABLE 2-3

Replicate Analysis of _Pitar_ Samples and NRC Lobster Hepatopancreas Tissue to Determine Analytical Precision

(Concentrations in ug/g dry weight)

Sample		As	Cd	Cr	Cu	Fe	Hg	Pb	Zn
Pitar on DM 3	--	--	--	--	--	0.051	--	--	
Pitar on DM 3	--	--	--	--	--	0.060	--	--	
Mean		--	--	--	--	--	0.055	--	--
RPD[1]		--	--	--	--	--	16.3	--	--
Pitar on DM 2	12	0.97	0.69	16	240	--	4.8	150	
Pitar on DM 2	12	0.97	0.73	16	240	--	4.3	150	
Mean		12	0.97	0.71	16	240	--	4.6	150
RPD		8	0	6	0	0	--	11	0
NRC Lobster Tissue-1		25.1	25.3	2.34	415	197	0.326	12.6	164
-2		27.6	25.8	2.18	406	191	0.301	9.85	164
-3		27.6	24.9	2.95	399	184	0.281	8.22	158
-4		26.6	26.2	2.21	412	188	0.29	10.0	159
Mean		26.7	25.6	2.42	408	190	0.300	10.2	161
Std. Dev.		1.18	0.57	0.36	7.1	5.5	0.02	1.8	3.2
RSD[2]		4.4	2.2	15	1.7	2.9	6.5	18	1.9
Certified NRC[3] Values		24.6	26.3	2.4	439	186	0.330	10.4	177
Std. Dev.		2.2	2.1	0.6	22	11	0.06	2.0	10
% Recovery		108	97	100	93	102	91	98	91

[1] RPD = Relative Percent Deviation
[2] RSD = Relative Standard Deviation
[3] Certified reference material distributed by the National Research Council of Canada

Table 3-1

Chemical Analysis of Sediment Collected at WLIS Disposal Site, August 1986
(Concentrations on a dry weight basis)

Replicate	A Top	A Bottom	B Top	B Bottom	C Top	C Bottom	Mean (±Std.Dev) Top	Mean (±Std.Dev) Bottom
	Reference							
Hg ppm	1.9	0.053	0.27	1.9	1.5	1.0	1.2±0.8	1.1±0.7
Pb ppm	99	91	87	59	52	43	79±24	64±24
Zn ppm	180	110	160	100	82	77	141±52	96±17
As ppm	5.0	2.1	3.8	3.8	3.6	4.3	4.1±0.8	3.4±1.2
Cd ppm	<3	5	<3	9	4	<3	---	---
Cr ppm	42	37	52	36	46	27	47±5	33±6
Cu ppm	59	42	46	33	27	16	44±16	30±13
Ni ppm	<26	<26	<26	<26	<26	<26	---	---
Fe ppm	27000	32000	29000	36000	29000	33000	28300±1150	33700±2080
% Tot. Carbon	3.58	2.31	2.48	1.98	3.52	1.66	3.19±0.62	1.98±0.33
% Tot. Hydrogen	0.71	0.61	0.62	0.66	0.52	0.60	0.62±0.10	0.62±0.03
% Tot. Nitrogen	0.25	0.18	0.21	0.19	0.16	0.11	0.21±0.05	0.16±0.04
COD ppt[1]	14.0	19.4	13.5	11.8	10.3	10.7	12.6±2.0	14.0±4.7
Oil & Grease ppm	373	277	274	111	87	80	245±145	156±106
Total PCB ppm[2]							0.09	

[1] Parts per thousand
[2] Single analysis of combined core sections
Note: Top = top 2 cm of core.
Bottom = remainder of core.

Table 3-1 continued.

WLIS-A

Replicate	A		B		C		Mean (Std.Dev.)	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Hg ppm	0.42	0.58	2.4	0.45	0.69	0.39	1.17±1.07	0.47±0.10
Pb ppm	270	<25	210	190	220	160	233±32	---
Zn ppm	280	140	160	170	210	210	217±60	173±35
As ppm	9.0	4.4	3.8	5.1	4.5	5.5	5.8±2.8	5.0±0.6
Cd ppm	8	<3	<3	5	8	8	---	---
Cr ppm	51	30	47	38	54	53	51±4	40±12
Cu ppm	100	64	95	73	110	89	102±8	75±13
Ni ppm	65	<26	46	<26	44	29	52±12	---
Fe ppm	26000	19000	27000	25000	24000	30000	25700±1500	24700±5500
% Tot. Carbon	2.91	2.69	3.10	2.64	2.10	3.16	2.70±0.53	2.83±0.29
% Tot. Hydrogen	0.56	0.49	0.64	0.47	0.56	0.79	0.59±0.05	0.58±0.20
% Tot. Nitrogen	0.20	0.19	0.20	0.21	0.26	0.29	0.22±0.03	0.23±0.05
COD ppt[1]	111	55.7	164	133	126	145	134±27	111±48
Oil & Grease ppm	1460	508	1150	1090	1100	650	1240±195	749±303
Total PCB ppm[2]							0.50	

[1] Parts per thousand
[2] Single analysis of combined core sections
Note: Top = Top 2cm of core.
Bottom = remainder of core.

Table 3-2

Physical Characteristics of Sediment from the Biological Samples
WLIS Disposal Site, August 1986

Station-Rep	% Coarse	% Med. Sand	% Fine Sand	% Silt/ Clay	
WLIS-REF-1	2	2	3	93	Dark olive gray organic clay (OH) with shell fragments
-2	6	4	3	87	Dark olive gray organic clay (OH) with shell fragments
-3	4	2	3	91	Dark olive gray organic clay (OH) with shell fragments
-4	3	6	11	80	Dark olive gray organic clay (OH) with sand and shell fragments
-5	5	4	4	87	Dark olive gray organic clay (OH) with shell fragments
WLIS-A -1	17	26	32	25	Dark gray silty sand (SM) with shell fragments
-2	15	32	38	15	Dark olive gray silty sand (SM) with shell fragments
-3	36	30	30	4	Dark gray poorly graded sand with gravel (SP)
-4	14	41	42	3	Dark gray poorly graded sand (SP)
-5	15	21	36	18	Dark gray silty sand (SM) with shell fragments

Table 3-4

Benthic Community Analysis of Sediment Collected at WLIS, August 1986

SPECIES	WLIS-A CENTER 1	2	4	REFERENCE 1	4	3
CNIDARIA						
Ceriantheopsis americanus	.	.	.	2	1	3
RHYNCHOCOELA						
Cerebratulus lacteus	3	2	1	.	.	1
Tubulanus pellucidus	12	5	1	2	2	2
Rhychocoela ST	1	1	.	.	.	.
PHORONIDA						
Phoronis mulleri	3	1	.	.	.	1
ANNELIDA						
Oligochaeta spp.	12	21	17	4	17	4
Polychaeta						
Ampharetidae						
Ampharete arctica	74	92	42	.	.	1
Amphitrite ornata						
Asabellides oculata	7	.	1	1	1	2
Capitellidae						
Mediomastus ambiseta	910	1020	307	102	219	194
Chaetopteridae						
Spiochaetopterus oculatus	1	.	.	.	.	.
Cirratulidae						
Tharyx acutus	62	75	159	.	.	.
Cossura longocirrata	.	.	.	2	2	2
Flabelligeridae						
Pherusa affinis	14	42	43	.	.	13
Glyceridae						
Glycera americana	4	11	7	.	.	1
Hesionidae						
Podarke obscura	2	.	.	.	.	.
Maldanidae						
Asychis elongata	5	.	.	.	.	1
Euclymene torquata	.	6	.	.	.	.
Euclymene zonalis	100	168	87	3	.	14

Table 3-4 Continued.

SPECIES	WLIS-A CENTER 1	2	4	REFERENCE 1	4	3
Nephtyidae						
Nephtys incisa	1	17	2	74	113	79
Nereidae						
Nereis succinea	.	5	1	.	.	.
Paraonidae						
Paraonis gracilis	.	.	.	1	.	1
Pectinariidae						
Pectinaria gouldii	4	6	.	.	.	.
Pilargidae						
Sigambra tentaculata	.	2	.	2	.	13
Phyllodocidae						
Eulalia bilineata	.	13	9	1	.	.
Eteone longa						
Paranaitis speciosa	.	1	5	.	.	2
Polynoidae						
Harmothoe extenuata	.	2	8	2	.	5
Lepidonotus squamatus	.	1	.	.	.	.
Sabellaridae						
Sabellaria vulgaris	8	2	99	.	.	.
Sabellidae						
Potamilla sp.	.	1	1	.	.	.
Scalibregmidae						
Scalibregma inflatum	.	.	5	.	.	.
Spionidae						
Nerinides tridentata	.	.	.	.	.	2
Polydora ligni	10	8	2	.	.	.
Polydora socialis	.	6	2	1	.	5
Spio fillicornis	.	4	.	.	.	.
Streblospio bendicti	66	54	.	1	.	.
Syllidae						
Autloytus prolifer	.	.	.	.	.	1
Terebellidae						
Polycirrus eximius	79	71	57	.	.	.
Nicolea juv.	.	1	.	2	.	5

Table 3-4 Continued.

SPECIES	WLIS-A CENTER 1	2	4	REFERENCE 1	4	3
MOLLUSCA						
Arcidae						
Anadara transversa	3	.	2	.	.	1
Lyonsiidae						
Lyonsia hyalina	.	7	1	.	.	.
Mactridae						
Mulinia lateralis	28	15	1	.	.	1
Mytilidae						
Mytilus spat	.	.	.	.	.	1
Nuculanidae						
Yoldia limatula	3	4	2	5	11	10
Nuculidae						
Nucula annulata	.	1	1	283	360	35
Pandoridae						
Pandora gouldiana	1	3	.	.	.	.
Solenidae						
Ensis directus	4	9	3	.	.	1
Tellinidae						
Tellina agilis	18	59	18	.	.	.
Macoma tenta	.	.	.	.	.	2
Veneridae						
Pitar morrhuana	3	2	.	3	1	3
Leptonidae	2	.	.	.	.	.
Gastropoda						
Prosobranchia						
Calyptraeidae						
Crepidula fornicata	.	.	3	.	.	.
Crepidula plana	.	.	3	.	.	11
Crepidula spp.	.	8	.	1	.	4
Nassariidae						
Nassarius trivittatus	14	9	62	.	37	7
Pyramidellidae						
Odostomia A	.	.	.	.	.	3

Table 3-4 Continued.

SPECIES	WLIS-A CENTER			REFERENCE		
	1	2	4	1	4	3
ARTHROPODA						
Crustacea						
Cephalocarida						
Hutchinsoniella macracantha	.	.	.	1	.	1
Amphipoda						
Gammaridea						
Ampeliscidae						
Ampelisca spp.	2	1	.	2	.	3
Corophiidae						
Corophium acutum	.	.	.	.	1	5
Erichthonius brasiliensis	.	.	.	.	.	16
Unciola irrorata	6	13	11	.	.	.
Photidae						
Leptocheirus pinguis	20	9	2	.	.	2
Stenothoidae						
Parametopella cypris	.	.	.	.	.	1
Caprellidea						
Luconacea incerta	.	.	.	.	.	1
Cumacea						
Diastylidae						
Oxyurostylis smithi	.	.	.	.	.	2
Isopoda						
Idoteidae						
Edotea triloba	.	.	1	.	.	.
Decapoda						
Caridea						
Crangonidae						
Crangon septemspinosa	7	6	6	1	1	4
Paguridae						
Pagurus longicarpus	1	1	1	.	.	.
Cancridae						
Cancer irroratus	1	3	6	.	.	2
Hemichordata						
Saccoglossus kowalewskii	2	2	.	4	.	.

Table 3-4 Continued.

SPECIES	WLIS-A CENTER 1	2	4	REFERENCE 1	4	3
Total number individuals	1493	1790	979	499	766	467
Polychaetes	1347	1608	837	192	335	341
Mollusca	76	117	96	292	409	79
Crustacea	37	33	27	3	2	36
Amphipoda	28	23	13	2	1	28

Table 3-5

Summary of Totals of Species and Individuals Among Major Taxa Collected at Western Long Island Sound Disposal Site, August 1986

	CENTER "A"			REFERENCE		
Species/station	55			47		
Total species	68					

Species Per Station By Taxa

	CENTER "A" Number	CENTER "A" %	REFERENCE Number	REFERENCE %
Polychaeta	28	50.9	19	40.4
Mollusca	14	25.4	12	25.5
Crustacea	7	12.7	10	21.3
Other	6	10.9	6	12.7

	CENTER "A"			REFERENCE		
Individuals/ sample	1493	1790	979	499	766	487
Mean individuals/ station	1421			584		

Individuals Per Station By Taxa

	CENTER "A" Mean Number	CENTER "A" %	REFERENCE Mean Number	REFERENCE %
Polychaeta	1264	89.0	296	54.0
Mollusca	96.3	6.7	260	44.5
Crustacea	32	2.2	13.6	2.3
Other	29	2.0	14.3	2.4

Table 3-6

Trace Metals (Dry Weight) in Body Tissues of *Nephtys*
Collected at WLIS Disposal Site, August 1986

Station	Concentration in ug/g							
	As	Cd	Cr	Cu	Fe	Hg	Pb	Zn
Reference 1	0.71	0.46	0.63	13	530	<0.05	3.1	160
Reference 2	0.73	0.39	0.54	12	490	0.098	2.7	150
Reference 3	0.74	0.48	0.72	13	570	0.076	3.0	160
Mean	0.73	0.44	0.63	13	530	---	2.9	160
Std. Dev.	0.02	0.05	0.09	1	40	---	0.2	10
WLIS-1	0.73	0.33	0.44	14	540	<0.05	3.8	130
WLIS-2	0.74	0.25	0.56	13	540	<0.05	3.5	130
WLIS-3	0.74	0.25	0.42	16	520	<0.05	3.7	140
Mean	0.74	0.28	0.47	14	530	---	3.7	130
Std. Dev.	0.01	0.05	0.08	2	10	---	0.2	10

Table 3-7

Trace Metals (Wet Weight) in Body Tissues of *Nephtys*
Collected at WLIS Disposal Site, August 1986

Station	As	Cd	Cr	Cu	Fe	Hg	Pb	Zn
	Concentration in ug/g							
Reference 1	0.12	0.08	0.11	2.2	90	<.008	0.52	27
Reference 2	0.13	0.07	0.09	2.1	86	0.017	0.47	26
Reference 3	0.13	0.08	0.12	2.2	97	0.013	0.51	27
Mean	0.13	0.08	0.11	2.2	91	---	0.50	27
Std. Dev.	0.01	0.01	0.02	0.1	6	---	0.03	1
WLIS-1	0.14	0.06	0.08	2.7	104	<0.01	0.73	25
WLIS-2	0.15	0.05	0.11	2.6	106	<0.01	0.69	26
WLIS-3	0.14	0.05	0.08	3.1	101	<0.01	0.72	27
Mean	0.14	0.05	0.09	2.8	104	---	0.71	26
Std. Dev.	0.01	0.01	0.02	0.3	3	---	0.02	1

Table 3-8

PCB Concentrations in *Nephtys* Collected at WLIS Disposal Site
August 1986

Reference	WLIS
Dry Weight (ppb)[1]	
420	<300
<570	<350
620	<400
Wet Weight (ppb)	
71	<58
<100	<69
105	<78

[1] Concentrations and detection limits as Aroclor 1254. See Methods section for discussion of relationship to other PCB mixtures. No other PCB mixtures were detected.

Table 4-1

Comparison of REMOTS Data from the August 1986 and October 1985 Surveys at WLIS

	Mean RPD (cm)	Mean OSI
WLIS Stations October 1985 (n=22)	1.62	3.18
WLIS Stations August 1986 (n=56)	2.16 ns	5.77 *
WLIS Reference August 1986 (n=22)	0.59 *	-0.70 *

Note: ns indicates that results of the comparison to the October data was <u>not</u> significantly different (Kruskal-Wallis, $p \geq 0.05$).
* indicates a significant difference ($p<0.05$).

Table 4-2

Comparison of Chemical Analysis of Sediment Collected in Long Island Sound (Concentrations on a dry weight basis)

	Greig[1]	Benninger[2]	WLIS-A[3]	WLIS-REF[3]
Hg ppm	0.5-0.6		0.39-2.4	0.05-1.9
Pb ppm	58-77	30-52	<25-270	43-99
Zn ppm	195-201	106-190	140-280	82-180
As ppm	ND[4]		3.8-9.0	2.8-5.0
Cd ppm	ND		<3-8	<3-9
Cr ppm	159-164		30-54	27-52
Cu ppm	122-154	44-96	64-110	16-59
Ni ppm	22.0-22.6		<26-65	<26

Note: [1] from Greig et al. (1977); results from two stations in the vicinity of WLIS, top 4 cm of cores out of grab.
[2] from Benninger et al. (1979); results from top 10 cm of one core collected in the vicinity of the CLIS disposal site.
[3] includes results from 0-2 and 2-10 cm core sections.
[4] ND = not detected.

Table 4-3

Comparison of Chemical Analysis of *Nephtys* Collected in Long Island Sound (Concentrations on a dry weight basis)

	Munns et al.[1]			
	On DM	Reference	WLIS-A	WLIS-REF
Pb ppm	4.7-8.9	2.6-4.4	3.5-3.8	2.7-3.1
Zn ppm	150-220	125-175	130-140	150-160
Cd ppm	0.5-2.7	0.9-1.8	0.25-0.33	0.39-0.48
Cr ppm	1.0-5.7	1.0-2.4	0.42-0.56	0.54-0.72
Cu ppm	36-64	22-33	13-16	12-13
Fe ppm	500-1100	430-790	520-540	490-570
PCB ppb[2]	610-838	186-375	ND[3]	420-620

Note: [1] from Munns et al. (in preparation); results from Field Verification Program (FVP) site in the Central Long Island Sound Disposal Site.
[2] Concentrations as Aroclor 1254.
[3] ND = not detected.

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