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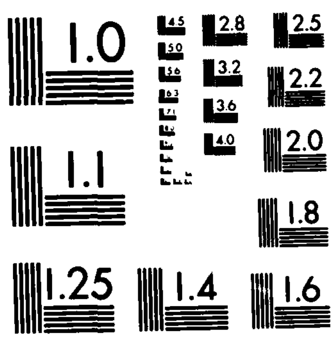

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TR 82-4

Performance of a Sand Trap Structure and Effects of Impounded Sediments, Channel Islands Harbor, California

by

R. D. Hobson

TECHNICAL REPORT NO. 82-4

OCTOBER 1982

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Monitoring of one complete filling cycle of a sand trap located at Channel Islands Harbor, California, has yielded textural and bathymetric data that (1) document patterns of infilling and sediment texture of the trapped sand, (2) compare coring versus surface grab sampling for describing native beach and fill sediment textures, and (3) determine the textural properties of trapped sediments and evaluate their performance as beach fill. This study was conducted at the conclusion of the Coastal Engineering Research Center's
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(CERC) long-term field investigation relating longshore transport volumes to wave energy thrust measurements. The data collected for this study consist of 28 vibratory cores of sediments, 8 cores from sites along a native beach profile, and 20 cores from sites within the trap. The long-term sediment transport study provided the remaining data used in this report.

In general, the trap functioned as designed, trapping the bulk of longshore transport which entered the trap mouth in a series of pulses or surges of sand. From an analysis of the textural data it is concluded that sediment distribution within the trap area is similar to that of the updrift coastline although the trapped sand is slightly finer and better sorted than the native beach sand. Also from the textural distributions within the trap, it is concluded that the "trapping" process slightly reduces the overall predicted performance of the sediment as beach fill but that bypassing could be planned to utilize the textural patterns in the construction of a beach fill downcoast. Finally, grab sampling rather than core sampling is the appropriate method for sampling native beach sediments, whereas either coring or grab sampling appears adequate for characterizing trap-fill sands.

PREFACE

This report is published to provide coastal engineers an analysis of the performance of a sand trap structure and the effects of impounded sediment on the structure. The work was carried out under the U.S. Army Coastal Engineering Research Center's (CERC) Beach-Fill Sediment Criteria work unit, Shore Protection and Restoration Program, Coastal Engineering Area of Civil Works Research and Development.

The report was prepared by Dr. R.D. Hobson, Engineering Geology Branch, under the general supervision of Dr. C.H. Everts, Chief, Engineering Geology Branch, and Mr. N. Parker, Chief, Engineering Development Division.

Special thanks are extended to C. Gable, who provided invaluable field and logistical support during the fieldwork in California; to R. Bruno, who supplied hydrosurvey data, Littoral Environment Observation (LEO) data, and data evaluation techniques; to the Naval Facilities Command, Washington, D.C., for the use of their vibratory corer; to the Commander and members of the Shops Crew of the Naval Civil Engineering Laboratory, Port Hueneme, California, who obtained most of the cores for this study; and finally, to E. Lagrone, U.S. Army Engineer District, Mobile, who provided technical training in use of the coring apparatus.

Technical Director of CERC was Dr. Robert W. Whalin, P.E., upon publication of this report.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

PERFORMANCE OF A SAND TRAP STRUCTURE AND EFFECTS OF IMPOUNDED SEDIMENTS, CHANNEL ISLANDS HARBOR, CALIFORNIA

by

R.D. Hobson

I. INTRODUCTION

Sediment traps are sometimes used in conjunction with jetties to intercept and collect littoral sand which might otherwise shoal in a navigation channel. The trap is positioned to interrupt the natural flow of sand transported along a coastline before it reaches the channel, and this sand is periodically dredged and bypassed downcoast where it is reintroduced into the natural transport system. A single updrift trap is used where longshore transport is dominantly unidirectional whereas twin traps may be employed to protect a channel where major transport reversals occur. A highly efficient trap that intercepts all longshore transport also provides an ideal location for determining the physical characteristics and composition, as well as accumulation rates and patterns of the sediments driven naturally by coastal processes. This study documents the filling history and sedimentary characteristics of one sand trap and evaluates how the results obtained may be useful to coastal engineers.

The study area at Channel Islands Harbor, California (Fig. 1), includes the "trap" as defined by the beach, the northern harbor entrance jetty and an offshore breakwater, and a "native beach" section located upcoast from the trap. Channel Islands Harbor, which is approximately 80 kilometers north of Los Angeles, has been the site of extensive field studies by the Coastal Engineering Research Center (CERC) in documenting longshore transport rates and determining accurate empirical relationships between nearshore wave thrust and sediment transport. The harbor was constructed along this high energy coast in 1961 with its entrance channeled between parallel shore-normal jetties located to the lee of a shore-parallel offshore breakwater (Fig. 1). The configuration was chosen to allow a protected harbor entrance to small boats regardless of the direction of incoming waves. The configuration of the breakwater and jetties is also unique because it acts as a nearly complete barrier to longshore transport. Waves arrive at Channel Islands mainly from the northwest and west (Fig. 1, direction 270°) due to shadowing of most other swell directions by the islands and by Point Conception to the north (Herron and Harris, 1966). The result is a generally southward drift which can be caught by a single sediment trap, dredged, and then bypassed. Reversals can and usually do occur yearly when swell from the southwest dominates (Fig. 1, swell direction 215°) but even during these periods, the breakwater configuration still causes the trap to continue filling from the north (Bruno, et al., 1981). Table 1 presents the dredging history of the trap since construction and indicates that the average yearly sand accumulation is about 720 000 cubic meters and that the trap usually fills in about 1.5 years.

II. DATA COLLECTION AND ANALYSIS

Sediment cores, hydrosurveys, surface sediment samples, and a coordinated set of process observations provide the basic data for this report. The coring was performed specifically for the reported study whereas the other data were collected in conjunction with the CERC study of sediment transport in the area.

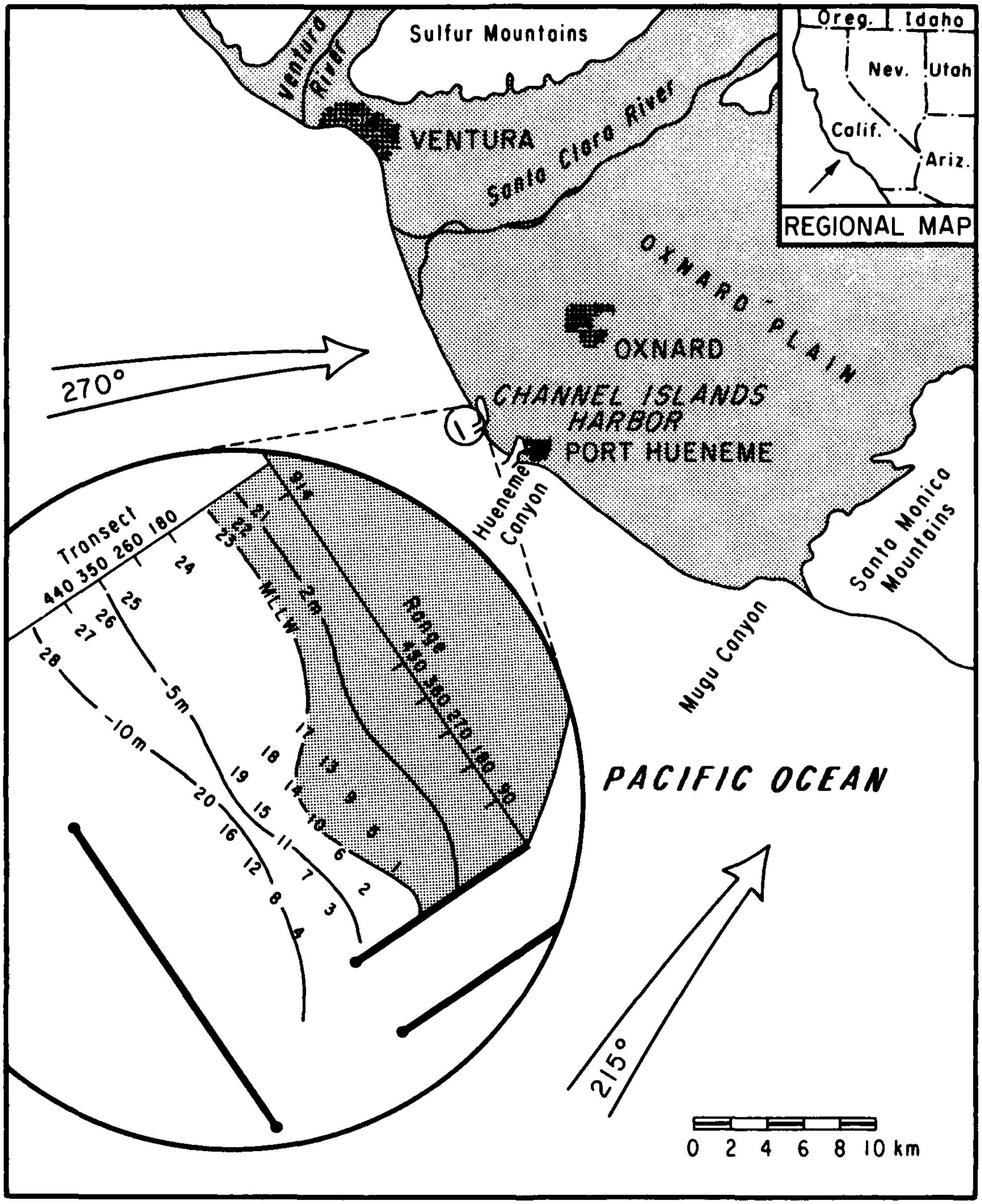


Figure 1. Location map showing coastal physiography with directions of unobstructed wave approach (270° and 215°) and inset of core locations (Herron and Harris, 1966).

Table 1. Trap maintenance history: Channel Islands Harbor, California.

Trap dredging dates	Fill time[1] (mo)	Dredge time[2] (mo)	Sand volume in trap (m^3)	Yearly accumulation (m^3/yr)
June 61[3]	--	-	1 278 000	-------
26 June to 6 Sept. 63	27	4	1 518 000	674 000
20 Apr. to 19 Sept. 65	24	6	2 696 000[4]	-------
2 Jan. to 29 Feb. 68	29	2	1 278 000	528 000
15 Sept. 69 to 6 Jan. 70	22	4	2 141 000[4]	-------
5 Aug. to 11 Dec. 71	23	4	1 835 000	956 000
20 Sept. 73 to 23 Apr. 74	28	7	1 338 000	574 000
8 Sept. to 18 Dec. 75	20	3	1 223 000	732 000
13 Nov. 77 to 16 Jan. 78	25	2	1 835 000[4]	463 000[5]
Mar. 80	26	-	1 514 000	698 000

[1]Time in months required for sand trap to fill.

[2]Time in months needed to dredge trap.

[3]Initial construction of sand trap completed.

[4]Sand trap enlarged, thus volumes shown are only partially the result of natural filling.

[5]Accumulation rate as determined from this study.

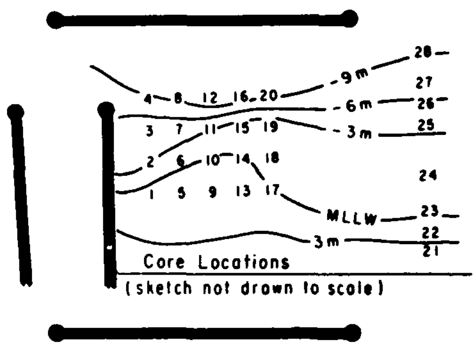
1. Sediment Cores.

Twenty-eight sediment cores were obtained using standard vibratory coring equipment. Twenty of the cores were taken in the trap area at locations that had been monitored and sampled bimonthly during the previous 18 months as part of the CERC sediment transport study. The remaining eight cores were taken at sites along a beach profile line located about 365 meters north of the trap. This profile is considered a "native beach" profile because it lies far enough updrift to be unaffected by the trap structures and thus provides a location for determining natural beach responses to normal coastal processes. The eight cores were sited by elevation along the profile line. The cores were obtained under private contract and with the assistance of the Naval Civil Engineering Laboratory, Port Hueneme, California. Table 2 contains the following specifics for the 28 cores: location, site elevation, core length, and thickness of sediments affected by erosion and deposition during the previous 18 months.

Core sites were located using an automatic electronic positioning system. Offshore coring was from a self-propelled crane-barge anchored on location by multiple anchors; a mobile crane was used to position the vibracorer at onshore locations. Vibracoring was to the desired depth as determined by surveyed elevation changes at each site or until the core would no longer penetrate into the substrate (refusal). Refusal occurred only once--at core 19, which was about 1 meter too short--before the desired minimum penetration was achieved.

Table 2. Vibracore specifics: Channel Islands Harbor, California.

Core	Core elevation (m)	Core length (m)	Active thickness[1] (m)	Core	Core elevation (m)	Core length (m)	Active thickness (m)
1	2.44	7.47	6.10	21	4.26	6.16	1.21
2	-3.35	4.27	2.74	22	2.43	6.19	1.76
3	-5.18	4.54	1.98	23	0	6.16	1.83
4	-8.23	3.08	1.89	24	-1.83	6.55	1.21
5	2.74	9.20	7.92	25	-3.66	6.19	0.91
6	-0.30	8.84	7.62	26	-6.40	5.33	0.30
7	-4.26	8.20	5.33	27	-7.32	6.04	0.45
8	-9.44	2.80	0.98	28	-8.84	4.75	0.45
9	3.35	4.15	3.05				
10	0.61	7.96	4.42				
11	-3.65	5.85	4.57				
12	-10.36	1.92	1.22				
13	3.05	4.32	3.35				
14	0.61	8.29	3.41				
15	-3.05	7.83	7.16				
16	-9.45	4.51	0.91				
17	0	5.58	2.59				
18	-1.83	5.39	0.91				
19[2]	-2.43	7.28	8.23				
20	-9.45	3.11	0.91				



[1]Active thickness is difference of highest and lowest surveyed elevation for 18 months preceding coring.

[2]Location where core length is less than active thickness.

The cores were retained in 7.6-centimeter-diameter clear plastic liners. Ultimately, these were split and the cores were photographed and the sediment channel-sampled (Krumbein and Graybill, 1965) within 0.3-meter intervals for textural analysis. Grain-size distributions were determined for each sediment sample using sedimentation tube size analysis techniques. Phi mean and phi sorting data for these samples appear in the Appendix.

2. Hydrosurveys and Surface Sand Samples.

The rate and patterns of trap infilling were determined from hydrosurveys, and surface sand samples were used to characterize the texture of trap-fill sediments. Twelve hydrosurveys were conducted between trap dredging episodes; five sets of samples were collected (Table 3). Monthly surveys using an automated system mounted aboard a LARC V amphibious vehicle were initially planned to monitor trap filling but actual times between surveys varied from 25 to 76 days to accommodate adverse weather, equipment failures, and scheduling difficulties. U.S. Army Engineer District, Los Angeles, personnel assisted with the surveys and with sand sample collection. Sand sampling was initially planned for alternate surveys with samples being collected by scuba divers, where necessary, at the same grid locations in the trap and along the same upcoast profile line as those locations subsequently cored in September 1977. Inclement weather prevented the planned sampling episode following the

Table 3. Survey and sand sample history:
Channel Islands Harbor, California.

Event		Date	Sand sampling schedule		
				Days[1]	Phase[2]
Start of dredging		13 Nov. 77			
Start of coring		Sept. 77			
HYDROSURVEYS	12	31 Aug. 77[3]	*		
	11	20 July 77		209	V
	10	7 June 77			
	9	23 Mar. 77			
	8	3 Feb. 77[3]	*		
	7	29 Nov. 76		122	IV
	6	4 Oct. 76[3]	*		
	5	8 Sept. 76		52	III
	4	12 Aug. 76[3]	*		
	3	28 June 76		83	II
	2	21 May 76[3]	*		
	1	19 Apr. 76		31	I
End of dredging		18 Dec. 75			

[1]Timespan for surface samples.

[2]Phase of trap fill.

[3]Surface sand samples (*) collected.

June 1977 survey, thus, only five sets of samples are available for textural comparisons of surface versus cored trap-fill sands. Since this report focuses on textural patterns and on sampling methods for describing sediment texture, the discussions in Section III concentrate on those five phases of filling that were surveyed and sampled. The phases are identified by Roman numerals with the largest numeral (V) representing the youngest phase of filling (Table 3).

3. Coastal Process Observations.

Data describing coastal processes were collected daily following the Littoral Environment Observations (LEO) scheme described by Balsillie (1975). These observations include (a) surf observations (surf zone width and breaker period, height, direction, and type); (b) wind observations (speed and direction); (c) foreshore slope; (d) longshore currents (speed, direction, and distance from coast); and descriptions of (e) rip currents and (f) beach cusps. These process data were mainly collected to quantify longshore transport rates and to test theoretical transport model predictions and thus are discussed only briefly in this report.

III. FILLING HISTORY

The five phases of trap filling (I to V), which vary in length, were established using the dates that hydrographic surveys and surface sand samples were simultaneously collected. Phase V, the most recent phase (Table 3), was initially planned as two phases but storms and equipment failures prevented sand sample collection during the June 1977 hydrosurvey. Finally, these phases are arbitrary divisions of trap-filling history and do not correspond to recognizable episodes of sedimentation.

Figures 2, 3, and 4, respectively, show cross sections of the cored trap-fill sediments, cored native beach sediments, and maps of relief and thickness changes that occurred in the trap as it filled. Cross sections are keyed to a mean lower low water (MLLW) elevation datum and are shown along four shore-parallel transects through the trap area (Figs. 2 and 3). Core numbers correspond to those shown in Figure 1 with base elevations for the trap bottom as dredged prior to monitoring. The presence or absence of a particular sedimentation phase (deposition or erosion) was determined by comparing sequential elevation changes for a location.

Three maps are used to show the patterns of infilling for each filling phase monitored (Fig. 4). These maps show (a) bottom elevations surveyed; (b) erosion-deposition patterns for a particular phase; and (c) cumulative erosion-deposition patterns within the trap. In addition, Figure 4 contains a core location key map, a map showing the original trap topography (labeled "prefill elevations"), and an additional sequence of three maps showing trap conditions monitored midway through phase V (labeled "phase V-1") which were surveyed on 7 June 1977 but not sand sampled. Phase V-2 (Fig. 4) shows the final trap conditions for which sand sample data are available. Finally, elevations and elevation differences shown on the maps are plotted at cored locations.

The trap filled in about 1.5 years and in general, three simultaneously occurring filling trends were observed: (a) filling occurred in pulses from updrift to downdrift trap locations; (b) nearshore locations filled before offshore locations; and (c) the rate of filling accelerated during the study period.

Phase I (31 days) filling occurred mainly along the updrift (north) shoreline of the trap (Fig. 2,a) and extended that shoreline about 25 meters seaward. Small thicknesses (about 0.33 meter) of phase I sediments were also found at core sites 2 and 18 on opposite ends of transect 260 but not in other intermediate cores, indicating the possibility of (a) deposition followed by erosion at those localities, (b) sediment redistribution along the southern margin of the trap (a reasonable explanation considering the erosional pattern in that area, Fig. 4, phase I), or (c) the apparent lack of phase I sediments may reflect survey errors which can be as great as these thicknesses (Bruno and Gable, 1976).

During phase II (83 days) the nearshore zone continued filling deeper (southward) into the trap and offshore as well. Along transect 170, exposed beach sites (cores 9 and 13) were raised more than 1 meter above MLLW while more than 2 meters of fill was deposited at sites 1 and 5. Other accumulations of less than 1-meter thicknesses occurred more generally throughout the trap, and it appears that phase I materials served as a transport path which allowed

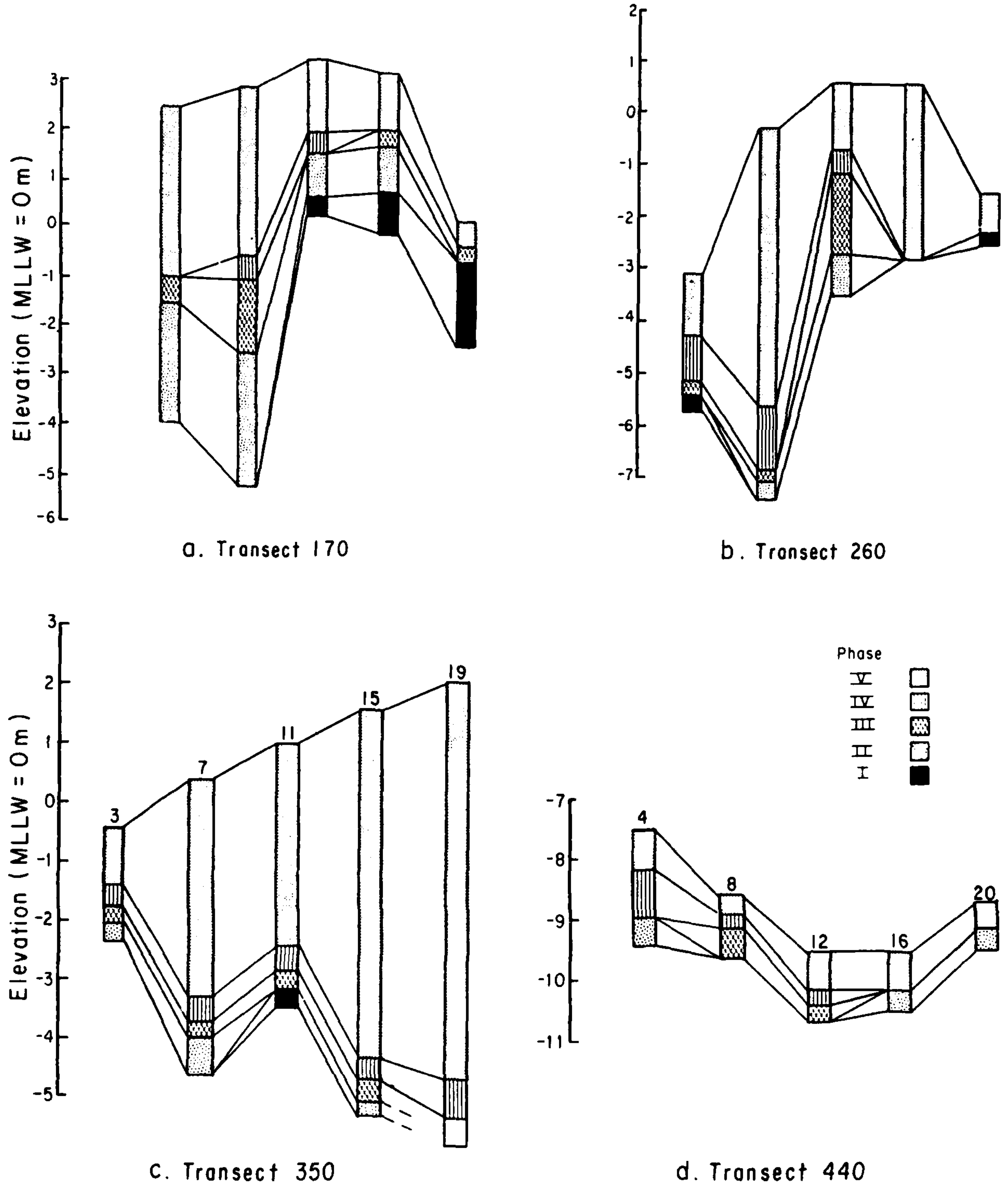


Figure 2. Cross sections of cored trap-fill sediment thicknesses for the five trap-filling phases (see Table 3).

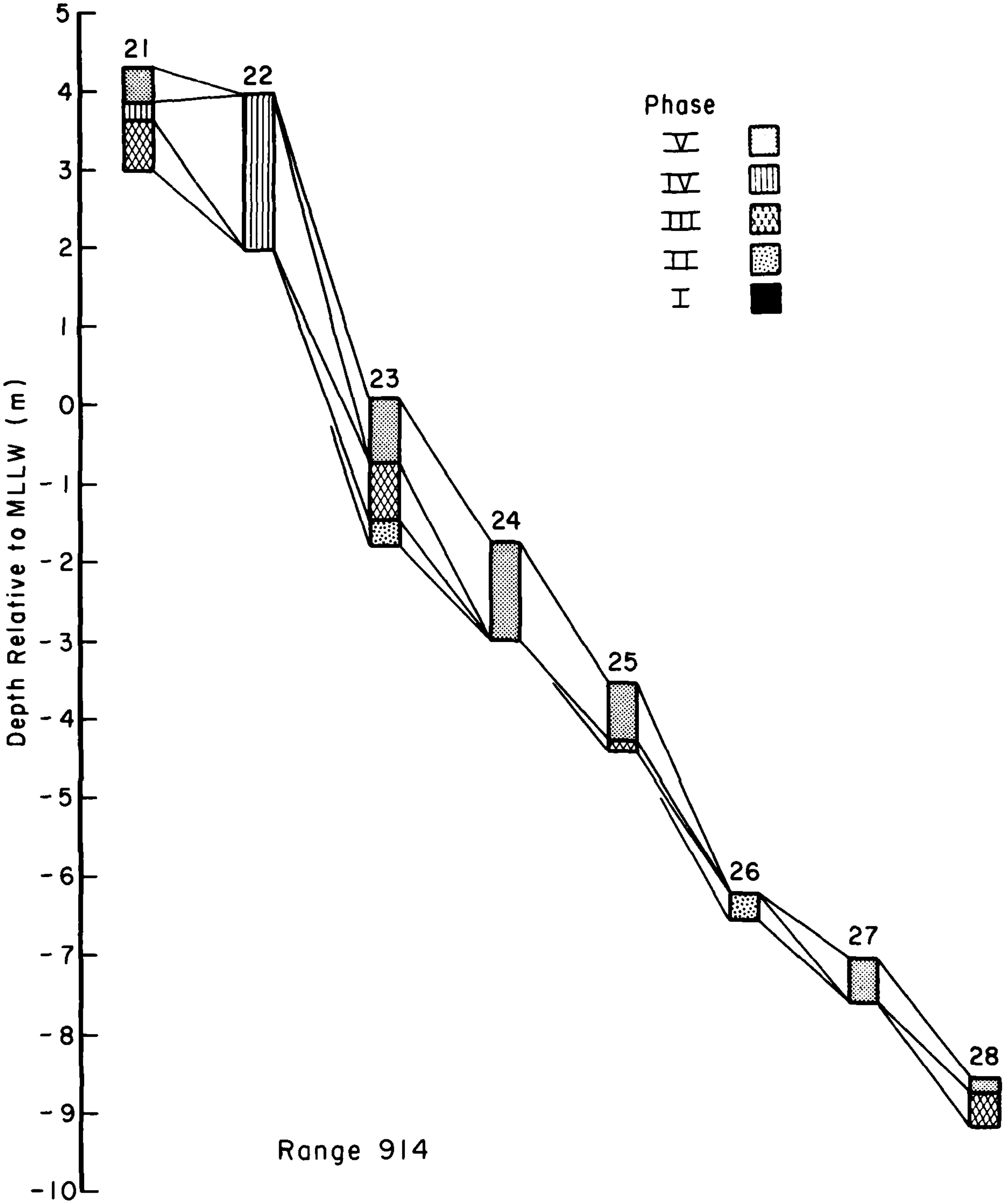


Figure 3. Cross section of cored native beach sediment thicknesses for the five study phases (see Table 3).

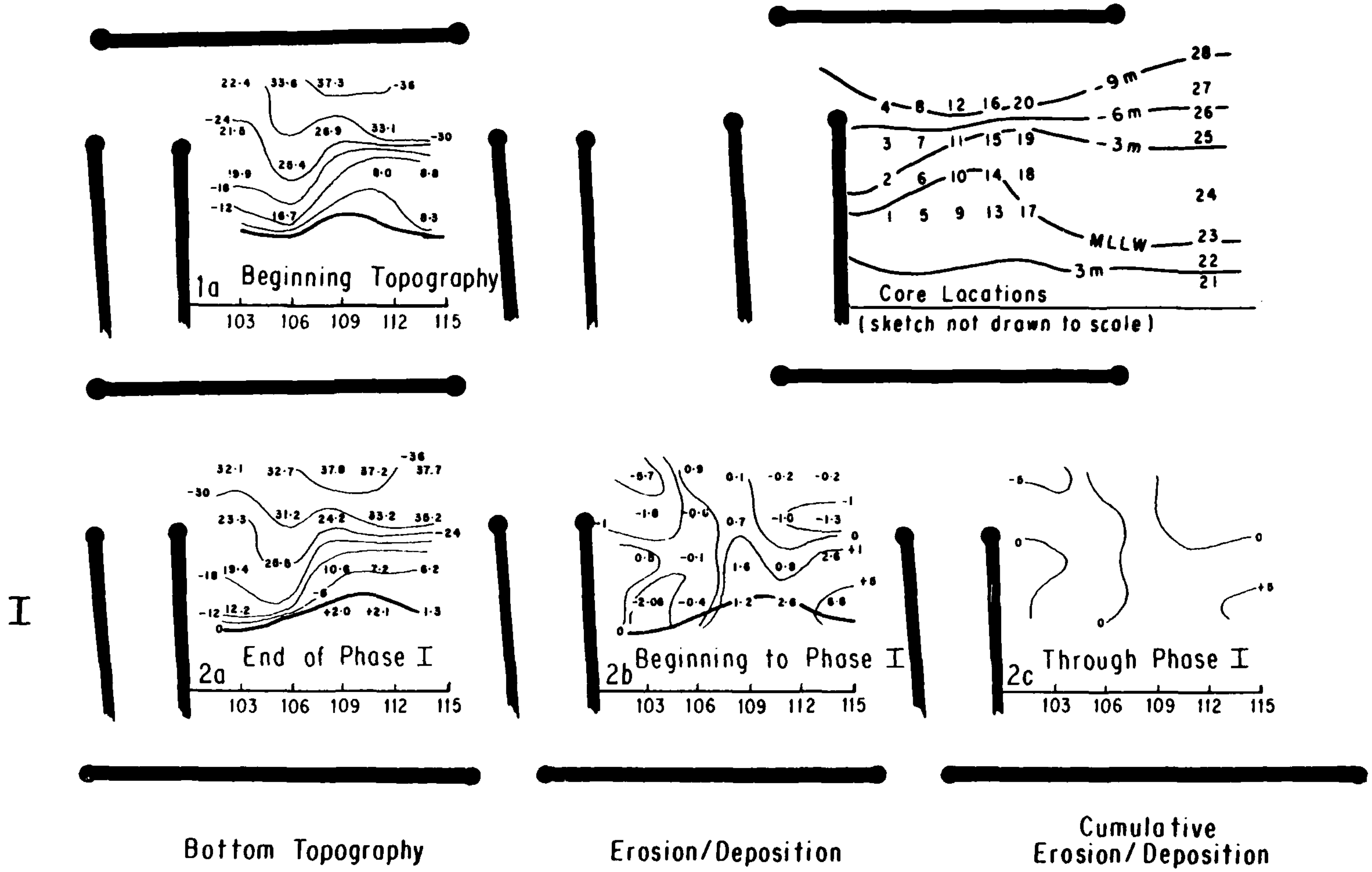


Figure 4. Sequential filling history of sand trap, Channel Islands, California.

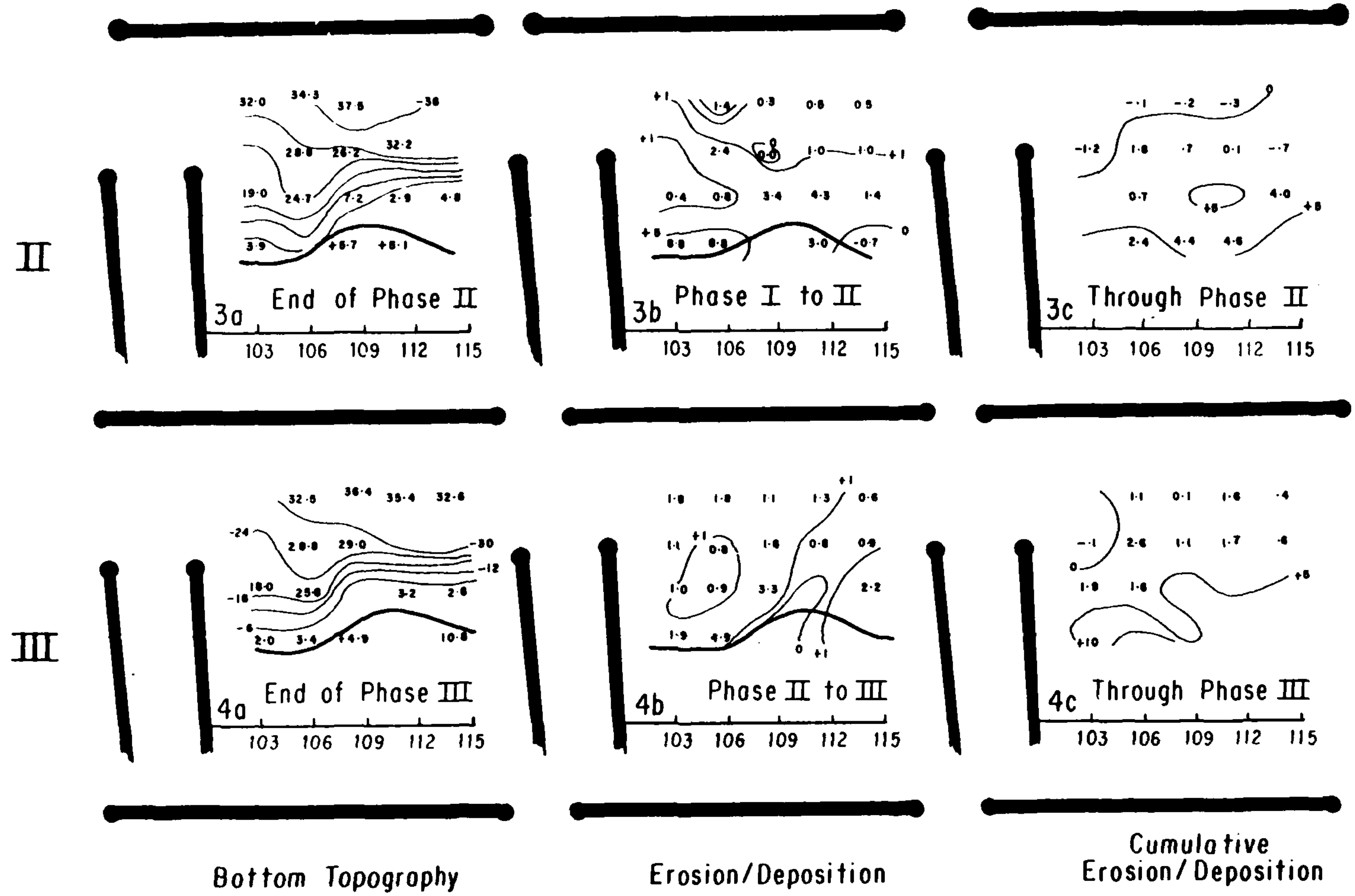


Figure 4. Sequential filling history of sand trap, Channel Islands, California.--Continued

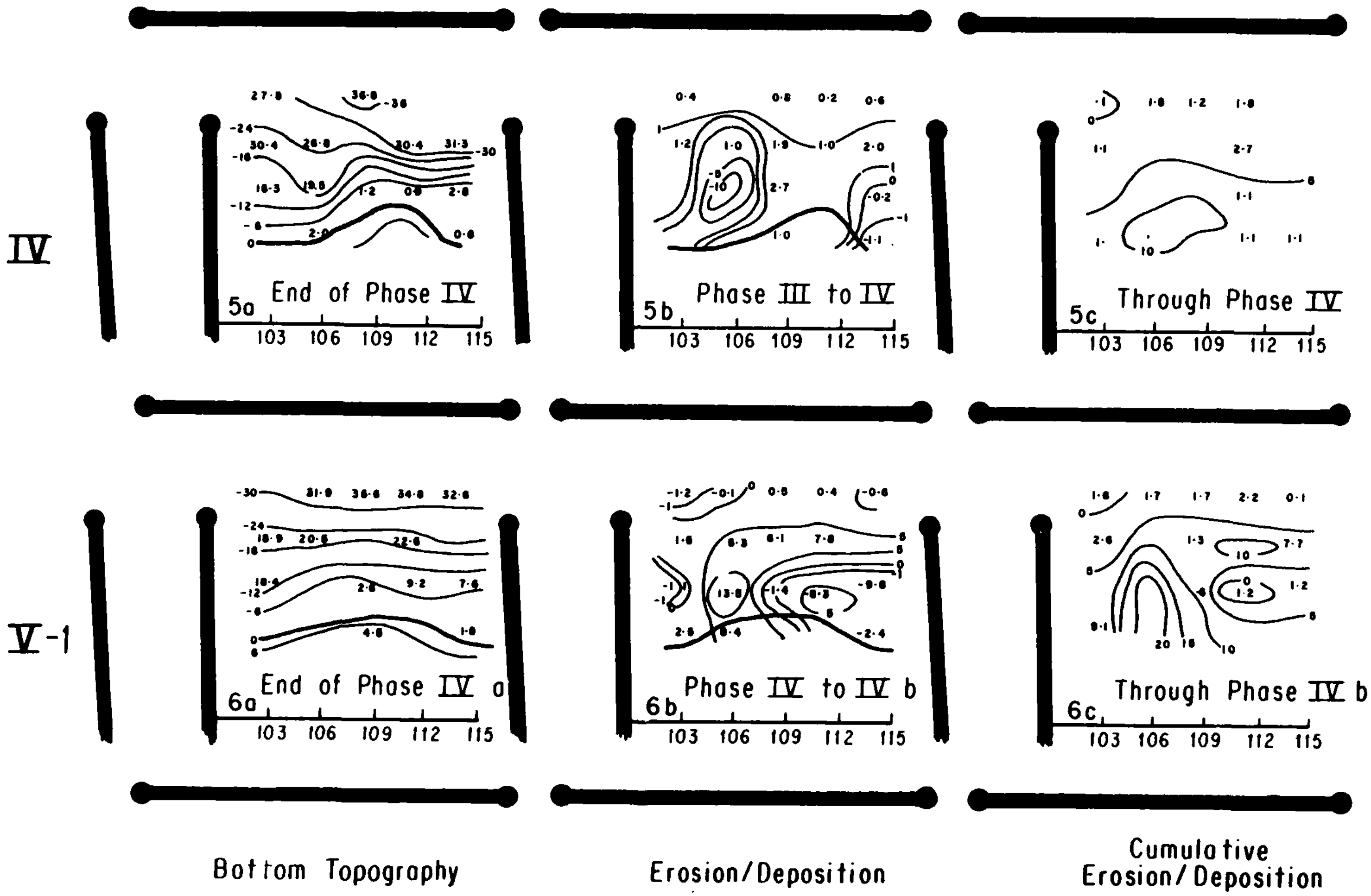


Figure 4. Sequential filling history of sand trap, Channel Islands, California.--Continued

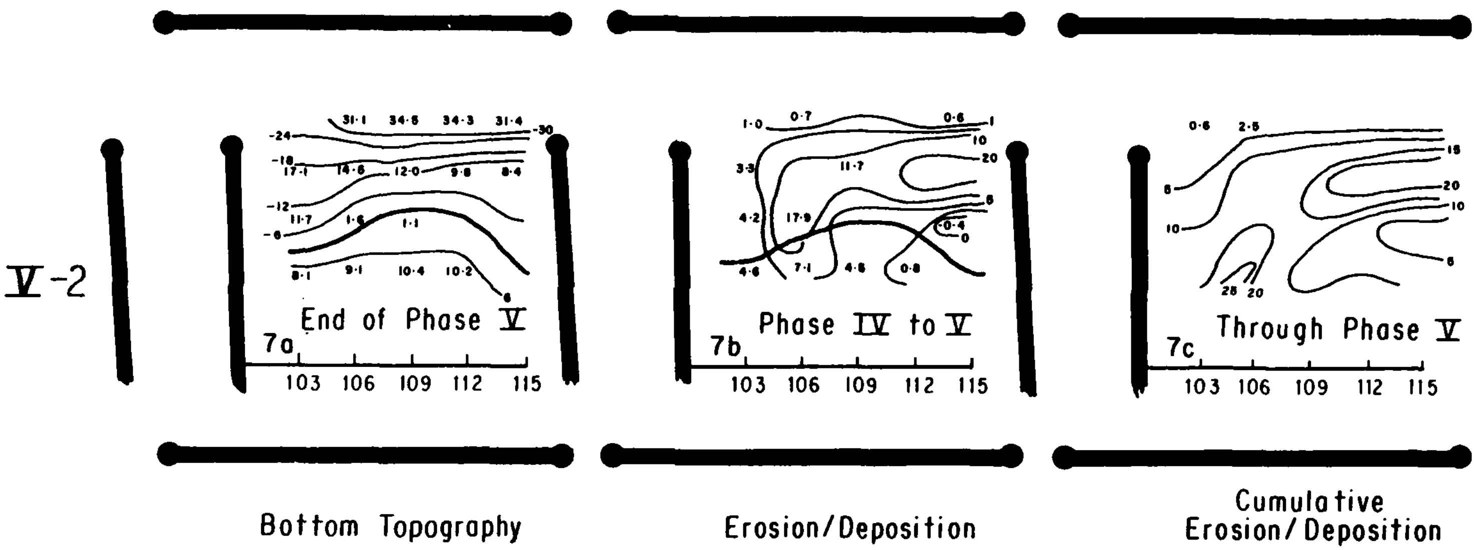


Figure 4. Sequential filling history of sand trap, Channel Islands, California.--Continued

high energy phase II waves to transport sand over the phase I pulse of sand into the deeper reaches of the trap.

Summer phase III conditions (52 days) favored the continuation of phase II depositional patterns. Sediments continued to move alongshore across the phase I-phase II "ramp" and into the nearshore portion of the dredged trap (e.g., about a 2-meter accumulation at location 10 and a little less at 5). The shoreline moved progressively seaward, about 0.50 meter of sediments accumulated at most offshore locations, and erosion of the nearshore ramp (cores 9 and 14) supplied sediments to the interior of the trap.

Phase IV (122 days) is characterized both by slow rates of sedimentation and by redistribution of sediments already deposited within the trap. Accumulations were greatest along transect 260 (about 1.50 meters at location 6) which continued the general seaward infilling of the trap as seen in previous phases. A deep scour pocket developed along range 180, whose position suggests that waves and currents from southerly directions may have entered the trap and produced the observed erosion. Phase IV was also a time of major deposition on the foreshore of "native beach" profile 914 (more than 2 meters at location 22, Fig. 3).

Phase V (209 days) was the time of most rapid deposition during which the dredged trap was essentially filled. Deposition was greatest in the offshore dredge pits with the innermost pit filling generally before the depression located offshore at the updrift entrance to the trap (e.g., compare the erosion-deposition plots for phase V-1 versus V-2, Fig. 4). Also erosion of the nearshore "ramp" occurred during the winter of phase V (Fig. 4, V-1, 6b), whereas during the spring and summer, deposition dominated both within the trap and on native profile 914 (Fig. 3).

Finally, Table 4 summarizes the rates and volumes and associated wave energy factors for the five trap-fill phases. These data are presented by Bruno, et al. (1981), and trap-fill volumes are accurate to ±5 000 cubic meters. In total, 629 000 cubic meters accumulated during the 15-month study period, which indicates a longshore transport rate of 463 000 cubic meters per year, the lowest yearly rate since construction of the harbor (Table 1). This low rate reflects the fact that this study was conducted during a time when wave energies were lower than average. In addition large volumes of sediment were transported into the trap during the relatively high energy winter and spring of 1976 which could not be included in the calculated rates because the surveying program was not begun until April 1976. Trap filling is usually greatest during the winter when wave energies are usually the largest.

Table 4. Summary of the rates, volumes, and associated wave energy factors.

Accumulation phases	Accumulated volume (m^3)	Accumulation rate (m^3/d)	[1] $P_{\ell s}$, longshore energy flux (N/s)	[1] I, immersed weight transport rate (N/s)
I	30,100	971	-197.6[2]	113.8
II	120,800	1,455	-94.1	164.3
III	68,000	1,307	-65.9	144.5
IV	102,500	840	-244.3	97.7
V	308,100	1,474	-287.3	168.6

[1] $P_{\ell s}$ and I values are taken from Bruno, et al. (1981).

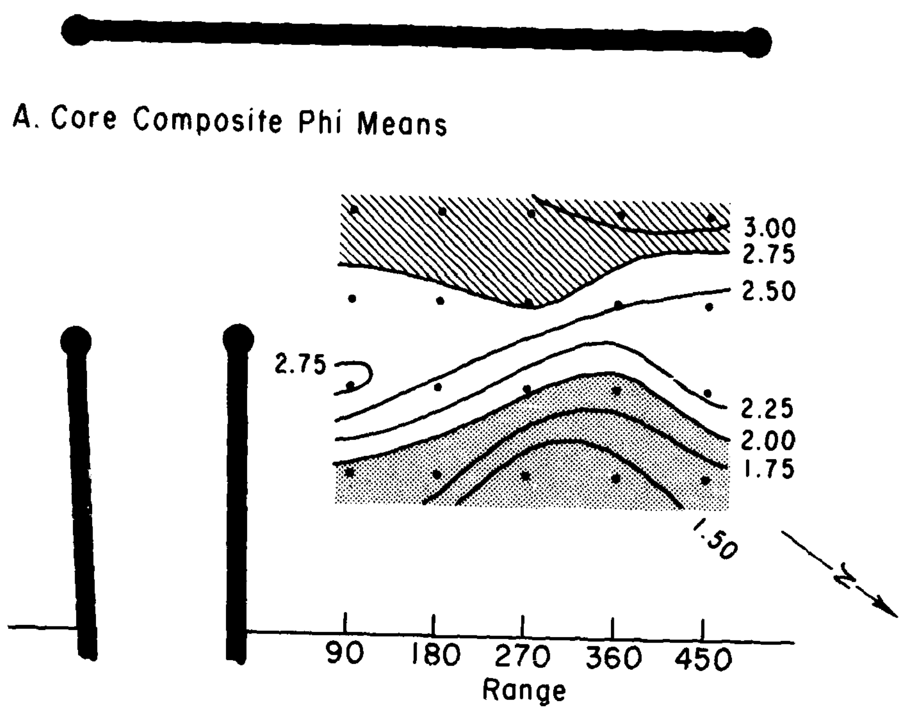
[2] Negative $P_{\ell s}$ values indicate sediment is transported toward the trap.

IV. TEXTURAL CONSIDERATIONS

Figures 5 and 6 provide phi mean and phi sorting values, respectively, for all sediments that accumulated in the trap during this study. Two maps of each variable are shown--one of composite grain-size parameters as determined by core sampling at the end of the study period and the other of surface grab samplings following the five study phases. In general, the patterns for each variable are similar, which suggests that either sampling technique is adequate for describing the trap-fill sediments. The sampling technique is discussed further in Section V.

In general, higher coastal energy conditions correlate with coarser grain sizes and more poorly sorted (well-graded) sediments. For example, coarse, poorly sorted sediments are usually found near the highly active plunge zone of a beach and both grain size and sorting decrease landward toward the foreshore and offshore as breaking and nonbreaking wave energy decreases, respectively. Longshore current velocities are generally greatest slightly landward and seaward of the plunge zone; as indicated, these areas of relatively high energy correlate with relatively coarser and more poorly sorted sediments. Mean grain size can be considered to reflect the severity of processes (waves and currents) and sorting the range of energies affecting a particular locality. Thus the plunge zone waves move the coarsest sands while finer materials are deposited between waves and at times when the plunge zone is shifted by tidal change; variations in wave and current energies at the bottom are much smaller offshore, resulting in finer, better sorted deposits. For this study, phi mean and sorting values are used to describe sediment texture. Phi mean values are based on a logarithmic transformation of grain size in millimeters and increase for finer sediments and decrease for the coarser; phi sorting values are dimensionless and describe the range of size grades for a particular grain-size distribution. Hobson (1979) gives further discussions of the phi grade scale.

Although the trap area is sheltered by the offshore breakwater, the textural patterns of sediments within it are similar to those characterizing an open coastline. The sand is coarsest and most poorly sorted in the nearshore zone. It becomes finer and better sorted offshore (Figs. 5 and 6). A cross section of phi mean and sorting along any range line within the trap is nearly identical to that found along native profile 900. The pattern of mean values (Fig. 5, A and B) suggests that the coarser material moved both alongshore, as far as the northern jetty, and into the central part of the trap (Fig. 5,A). This "bulge" of coarse sediments on the map is matched by a similar pattern of poor sorting (Fig. 6,A) and appears to represent the redistribution of nearshore transport path sediments discussed in the previous section. Patterns of sorting values generally imitate those for phi means although contour positions shift for core versus grab samples. For this study, poor sorting coincides with the coarser sands and better sorting with fine sediments. The best sorted sediments occupy an offshore position in the southern end of the trap, as would be expected, but the position of these well-sorted sands ($S\phi < 0.60$) lies more shoreward for grab samples than for core (Fig. 5, A versus B). The zone of the best sorted grab samples lies immediately to the lee of the northern harbor entrance jetty with poorer sorting toward the offshore breakwater, suggesting that waves and currents from the south may enter the trap between the breakwater and jetties and produce locally higher energy conditions which redistribute surface sediments. For core samples, the zone of best sorting is in the southwest corner of the trap, which may reflect the fact that most sediment



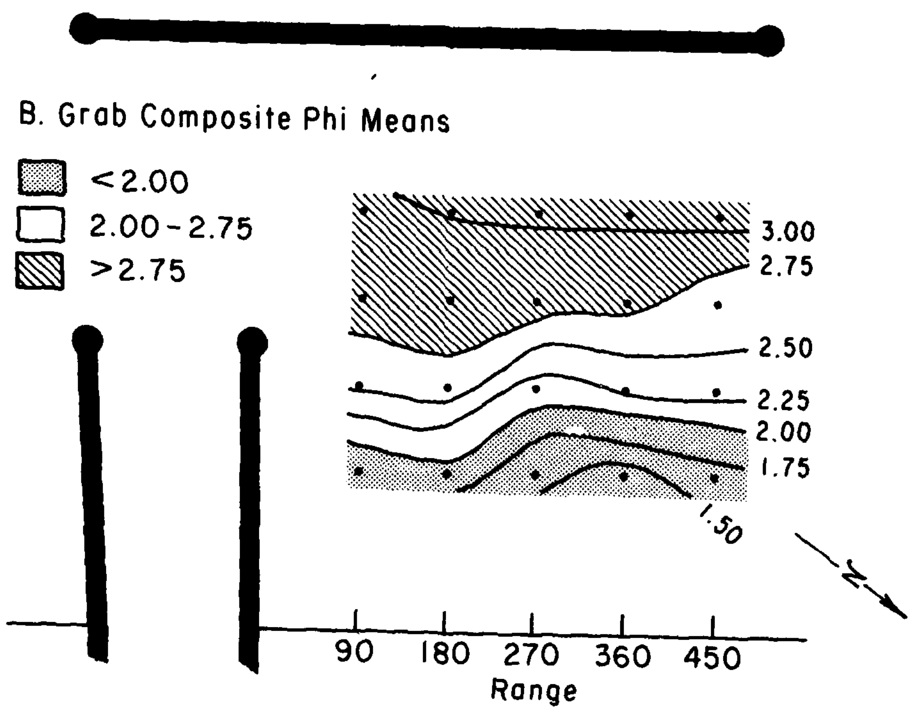


Figure 5. Composite phi mean maps of core (A) and grab (B) sediment samples within trap area.

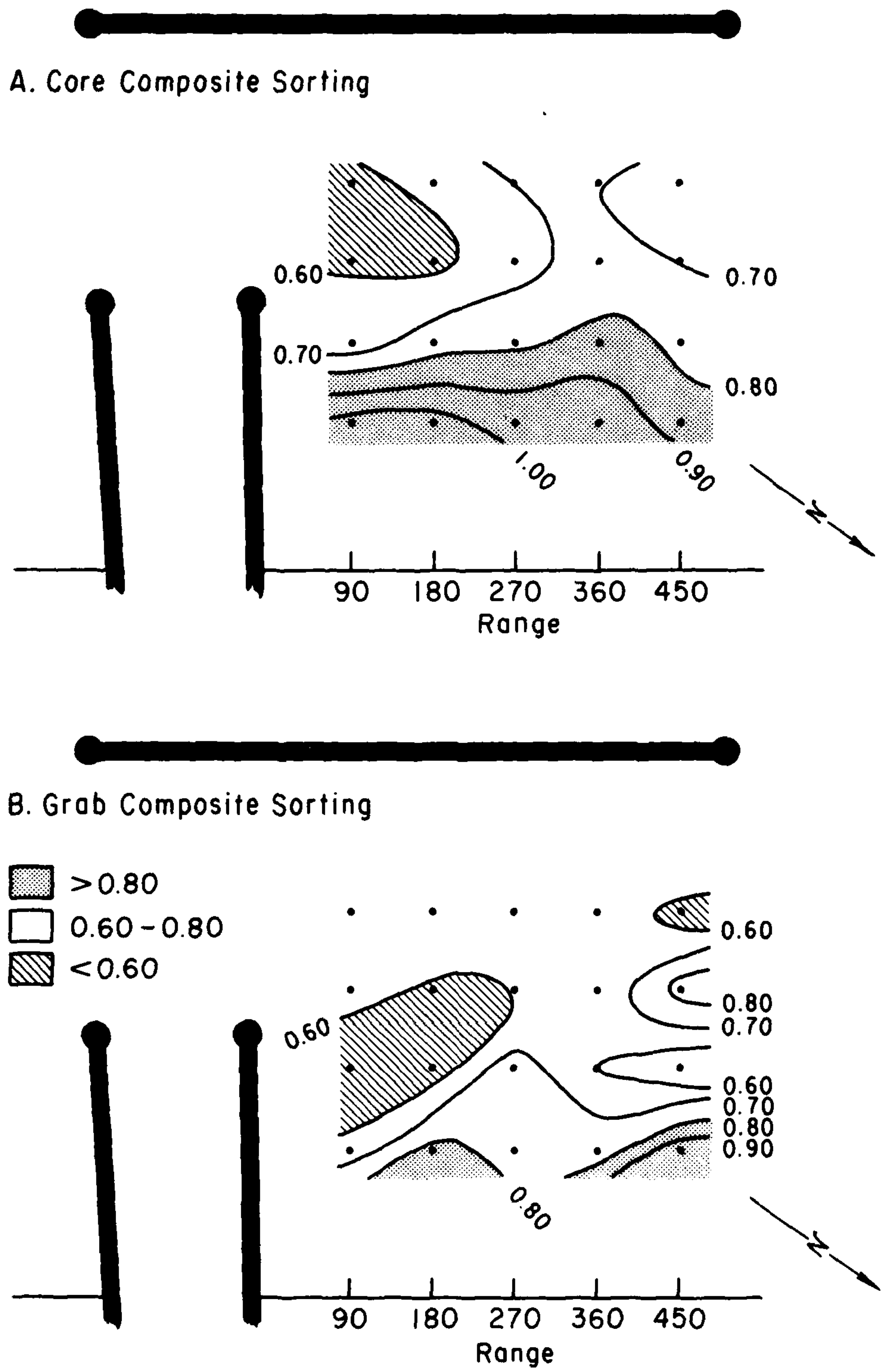


Figure 6. Composite phi sorting maps of core (A) and grab (B) sediment samples within trap area.

accumulated during rapid pulses of influx, was buried quickly, and therefore became unavailable for modification by waves and currents entering the trap from the south.

In conclusion, the textural distribution of trap-fill sediments is similar to that found for the unprotected updrift beach indicating that at least during periods of rapid sedimentation, current and wave energies in the trap were sufficient to redistribute most sizes of littoral drift sediments. Also, although patterns of composite mean and sorting values in the trap are similar for core versus grab sediment samples, the grab samples are slightly finer and better sorted than the core samples. These slight differences seem mainly due to minor postdepositional sorting rearrangements of surface sediment layers.

V. SAMPLING AND SEDIMENT TEXTURE

1. Sampling.

Core sampling and surface grab sampling techniques were employed to characterize both native beach and trap-fill sediments. The two methods were chosen to determine if textural differences existed between the composite grain-size distributions obtained, and if there were differences, to evaluate their effects upon the predicted performance of trapped sediments as beach fill. In addition, data obtained using the two sampling methods would be used with other similar data to evaluate sampling techniques for characterizing beach sediments.

As described earlier, surface samples were collected at 20 trap sites and at 8 sites along "native" profile line 914 at the end of each fill monitoring phase of the sediment transport study, and cores were obtained at these same sites after completion of the study. Differences between minimum and maximum elevations as surveyed during the study period (Table 3) were used to determine the core length needed at each site to sample sediments involved in active transport (Table 2, active thickness). It should be noted that these elevation differences may reflect dissimilar interpretations for trap versus native beach process-response relationships.

Although some erosion and sediment redistribution occurred in the trap during the study, minimum surveyed elevations generally were close to bottom elevations as dredged at the start of the study. The trap then generally "filled like a bucket" with sediments entering from the north and filling the dredged depressions to the final maximum elevations surveyed. Local redistribution within the trap caused only slight variations in this simple filling process.

This "bucket" analogy, however, cannot be applied to the beach. Here, the lowest elevation simply measures the deepest scour or erosion surveyed and the highest elevation, the greatest deposition at a location. Beach scour generally occurs during storms and scoured sections generally contain coarse lag deposits that grade upward into finer sands that are deposited as the beach is rebuilt by smaller poststorm waves. At Channel Islands, erosion was not the greatest at the beginning of the study nor did it necessarily affect the entire profile equally. Also, elevations were higher at some locations during the study than when the profile was cored. Therefore, the sediments contained within the active profile at any particular time are most likely to be a mixture of one or more coarse storm-lag layers overlain and interlayered with finer sands associated with nonstorm longshore transport.

2. Sediment Textures.

a. Composites. Composites are single representative grain-size distributions for a particular sediment population and are obtained by averaging the grain-size distributions of a series of samples collected to represent each population (Hobson, 1977). At Channel Islands, sampling was accomplished both by coring and grab methods for the native beach and sand trap sediment populations. Figure 7(A) shows size frequency plots for these four composites along with their phi mean and sorting values.

In general, sands found within the trap are slightly finer and slightly better sorted than native beach sands, as would be expected, since energy conditions within the sheltered trap area should be less than on the exposed native coastline. The unexpected relationships found on this plot are (1) the similarity of both trap composites to the grab-sampled native composite and (2) the great dissimilarity between these three distributions and the cored native beach composite.

(1) Similarity. Both composite distributions for trapped sediments are essentially the same suggesting that either sampling technique is adequate for describing these sediments and that their texture was accurately described. Also, the similarity of fill to the grab-sampled native composite would suggest that trap-filling processes (waves and currents) were sufficient to transport most native beach sediment sizes into the sheltered trap basin. In other words, the similarity of these three composites supports the idea that the Channel Islands structures do essentially trap all longshore transport; thus, the sediment volumes trapped, if accurately surveyed, can be used directly to evaluate various longshore transport models.

(2) Dissimilarity. The cored native beach composite is quite dissimilar to the others in Figure 7(A). These sands are coarser by about 0.1 millimeter and are much more poorly sorted. Also, the distribution is bimodal, possibly trimodal, with a fine mode at about 2.5 phi, about the same as the mean values for the other three composites, and coarse modes at about 1.0 phi and possibly near about 0.0 phi as well. The presence of these coarse sizes creates several interpretive paradoxes including: (a) Can the profile 914 data actually be considered representative of native beach conditions? (b) Are these coarse, cored sediments being deposited in the trap or is the beach actually "coarsening" and perhaps enlarging updrift of the trap? (c) Is coring the "active profile envelope" a useful approach generally for characterizing native beach sediments?

b. Native Profile. Profile 914 lies about 400 meters upcoast from the northern end of the offshore breakwater, and waves and currents occurring at this location are assumed to be unaffected by the structure except possibly during rare periods of current reversal. This assumption is based on diffraction calculations of waves passing a single breakwater (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977). For the most part, currents are driven steadily southward by waves from the west with intensities consistent for this coast. The rare current reversals are caused by waves from the southwest (Fig. 1, 215°) but at profile 914, the breakwater-refracted waves still produce a weak, southward longshore current capable of moving some sand into the trap (Bruno, et al., 1981). Although these periods of "reversals" might cause winnowing of finer sands from the sediments at profile 914, the

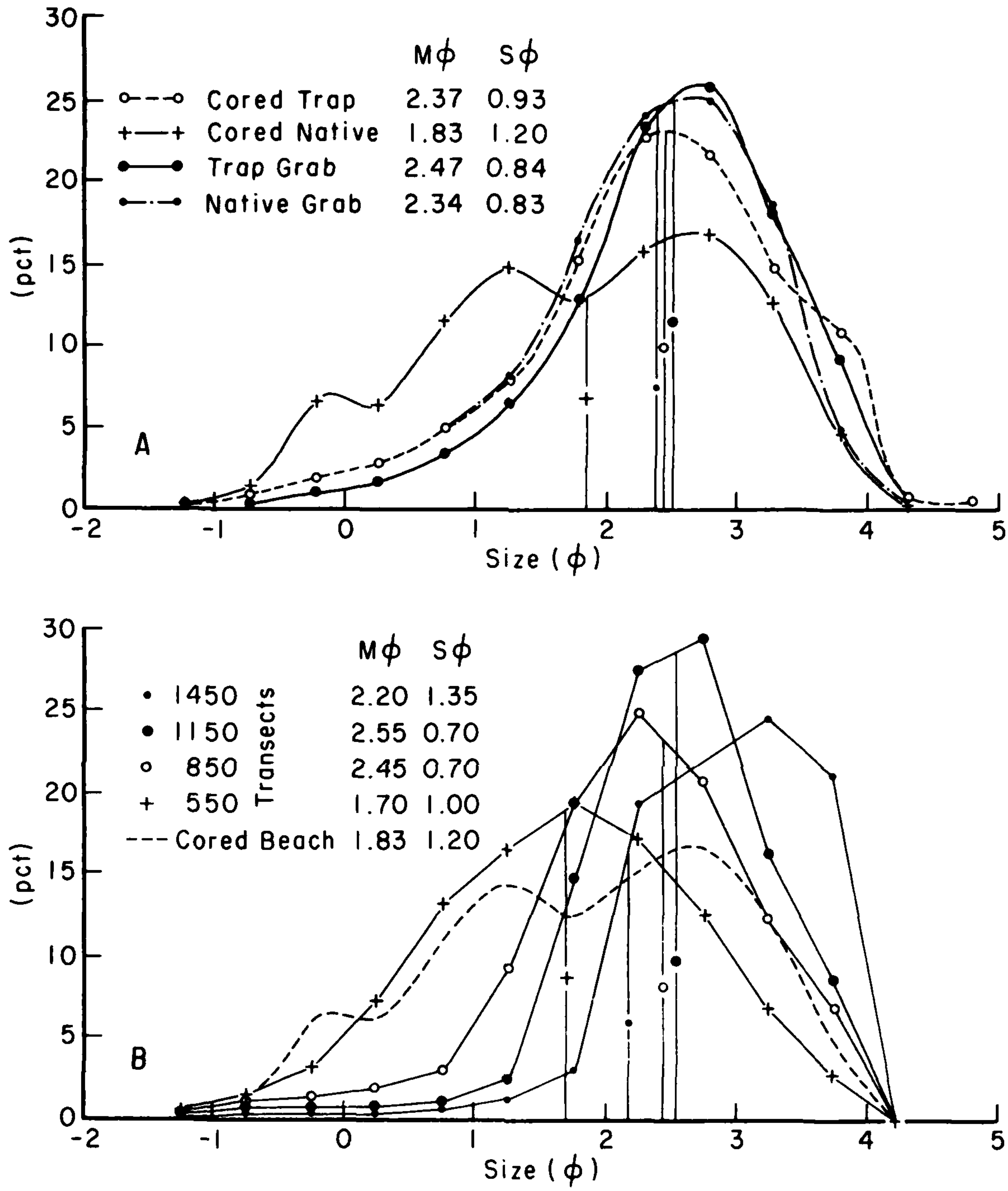


Figure 7. Frequency grain-size plots comparing (A) core versus grab composite distributions and (B) composite distributions for core transects within trap area.

amount of sand involved is negligible in terms of the total sediment volume transported; thus, winnowing is considered an inadequate explanation to account for the coarse texture of the cored native beach sediments.

c. Coarse-Grained Trap Fill. Similarities of all but the cored native composites in Figure 7(A) suggest that all native sand sizes are being carried into the trap. Figure 7(B) confirms this interpretation. This figure shows grain-size composites for sediments cored along the four shore-parallel transects within the trap (solid lines) compared with the cored native profile composite (dashline). Each transect composite is unimodal, the average grain size generally decreases toward seaward transects, and the total range of sizes for these composites encompasses those cored from the beach. Although not shown, composite grain-size distributions for each core location along a specific transect are similar, indicating that although the intensity of sedimentation processes decreased offshore, the intensities alongshore were essentially the same from the updrift to downdrift end of the trap (Figs. 5 and 6).

From these relationships it can be inferred that sediment transport processes were at least periodically able to move the coarsest native beach sediments into the trap, but that the amount of coarse fill is much less than the amount core-sampled at profile 914. If the cored native composite is an accurate sample of native beach sediments, then perhaps selective sorting is occurring and only finer sands are reaching the trap. If so, a coarsening of native sediment through time might be expected at profile 914 or perhaps, a buildup through time of coarse (untransportable?) sand should be observed close to the mouth of the trap.

Textural composites of sediments collected along profile 914 after each study phase (not shown) are almost identical with phi means ranging between 2.24 and 2.36 phi (0.21 and 0.19 millimeter) and sorting values between 0.75 and 1.00. The coarsest and most poorly sorted 2.24 and 1.00 phi) were for phase V samples, but these differences are too small to be considered a "trend" of beach coarsening through time.

Figure 8 shows shoreline shifts between surveys for profile 914 and for three other profiles between it and the sand trap entrance. The general "sawtooth" patterns for the profiles show multiple erosion-accretion sequences which tend to dispel the idea of overall updrift beach accretion. Also, maximum extensions and retreats of the shoreline occurred at different times for each profile and somewhat sequentially as well. For example, shoreward-retreating maximums observed for the period covered by the first seven surveys appear, in order, at profiles 914, 822, 670, and 762, while the corresponding order of seaward maximums are at 762, 914, 822, and 670. These staggered patterns seem to suggest that sand moved through the area in the form of "waves" or pulses that tended to swell and shrink the shoreline with their passage. This conceptual model of sediment pulses is also supported by the varying rates of trap filling discussed in a previous section. Figure 8 also reveals that there are times when either general accretion or erosion dominated the area (e.g., accretion at the time of surveys 6, 8, and 12 and erosion for surveys 4, 9, and 11). These trends of dominant accretion or erosion generally alternate and are consistent with the model of longshore transport occurring as pulses in the area. Finally, although the last survey of this study does document a general buildup of sand updrift of the trap, this buildup is interpreted as the next pulse of sediment transport to affect the area rather than as accumulation of sediments too coarse to be transported into the trap.

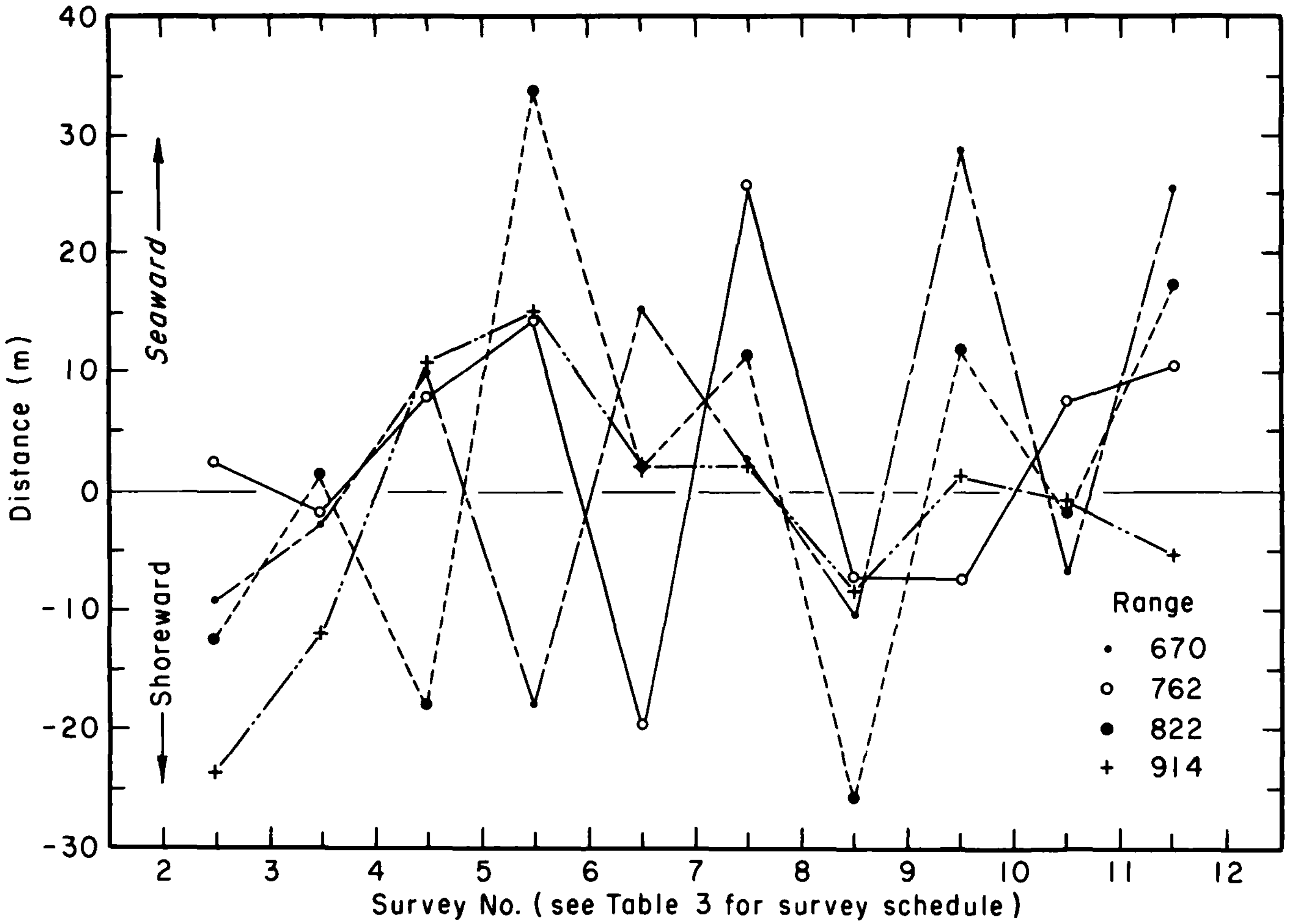


Figure 8. Relative shoreline shifts for native beach profile lines located updrift (N.) of trap. (Each plotted point shows measured differences for MLLW position for each survey interval.)

From the evidence presented in the previous paragraphs, it is concluded that (1) updrift sediments did not become significantly "coarser" during this study and (2) there was no significant updrift buildup of sediments. Rather, sediments were transported downdrift into the trap as a series of pulses or "waves," and transport conditions were such that all sizes available were transportable into the trap, even into its deepest reaches.

3. Coring and "Envelope."

From the two previous sections it appears that for this study, cored samples did not accurately describe the texture of native beach sands since the cored composite was coarser and more poorly sorted than all other composite estimates. These differences imply that either the criteria used to define the cored envelope or the coring and sampling procedures themselves may be suspect as a means for describing beach sediments. There is no doubt here that all sediments cored were recovered and sampled and that there were no losses or gains to contaminate the samples. Since the samples appeared representative, the coring criteria were examined.

Elevation maximums and minimums were used to define the active profile envelope and, as discussed earlier, sediments contained within the envelope, as cored, represented both storm (coarse) and nonstorm (finer) deposits; the interlayering of these two sediment populations was most pronounced at shallower water depths within the nearshore zone. Elevation maximums and minimums were also greatest at shallower nearshore depths. Figure 9 shows some of these sedimentary relationships for core segments taken from the native beach and segments from the trap.

For the native beach, sediments are much coarser inshore (Fig. 9, core 23) than offshore (core 25). There are few individually identifiable layers within the offshore core and grain sizes are nearly alike, whereas the inshore core is characterized by alternating coarse- and fine-grained layers of varying thickness. In addition, coarse-grained layers commonly fine or grade upward within a layer (core 23) indicating a gradual waning of depositional energy. Graded layers like these typify storm deposits where coarse sands and gravels are overlain by successively finer sands deposited as the storm abates. Interspersed between the storm layers are finer layers representing normal nonstorm deposition. Scour depths would depend on the intensity of a specific storm; thus, the active profile envelope at any particular moment could contain one or more graded storm layers as well as a variable number of nonstorm layers. The offshore profile would also be affected by storms, but both textural variations and the thickness of the profile envelope would be smaller offshore than closer inshore because the energy conditions themselves vary less at greater water depths. As a result of these relationships, nearshore deposits within the active profile are both the thickest and the most variable, and thus can significantly affect composite textural calculations. Coring during one day might result in a fine, well-sorted composite whereas another day's composite might be much coarser. Since the purpose of a composite is to describe an average sediment population, the unpredictability associated with coring the active profile envelope makes this an unsatisfactory sampling approach.

Cores taken in the sand trap are quite similar for each water depth to those from the native profile (e.g., Fig. 9, core 5 versus core 23, core 7 versus core 25). The offshore sediments (core 7) are well sorted and nearly

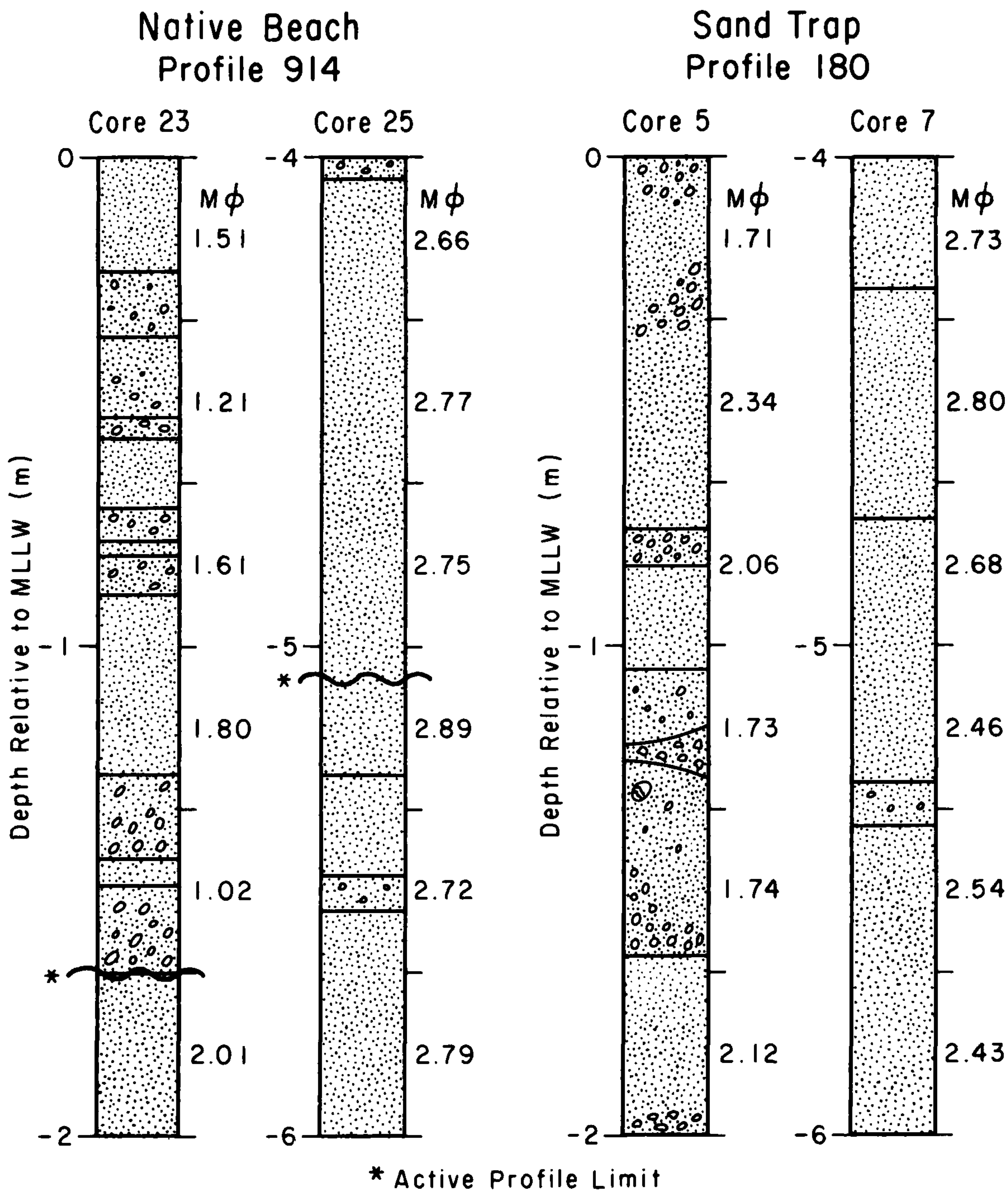


Figure 9. Sediment characteristics for selected native beach and sand trap cores.

the same size as the native profile sands from core 25. The inshore relationships are also similar with core 5 containing alternating coarse and fine layers and graded layers which again reflect both storm and nonstorm depositional influences. The main differences between the shallow-water cores is that the trapped sediments are generally finer grained than those cored from the native beach (core 23) which, for these particular data, suggests that the trap fill contains less storm-deposited material than found in the native profile envelope.

One method for estimating the importance of storms for filling the sand trap is to identify storm and nonstorm grain-size distributions and to determine the contribution of each in making up the cored beach and trap-fill sediments. This can be done following the polymodal interpretive methods proposed by Sinclair (1973) and Ashley (1978), who assume that nonnormal grain-size distributions can result from the mixing of normally distributed grain-size populations which are themselves associated with specific depositional environments. A graphical procedure has been developed for identifying component normal distributions from the analysis of nonnormal cumulative grain-size plots and for determining the proportions of the normal components needed to accurately reproduce the distributions of interest (see Ashley, 1978, for a complete discussion of this interpretive approach). Figure 10 shows the results of this technique applied to the cored Channel Islands composites.

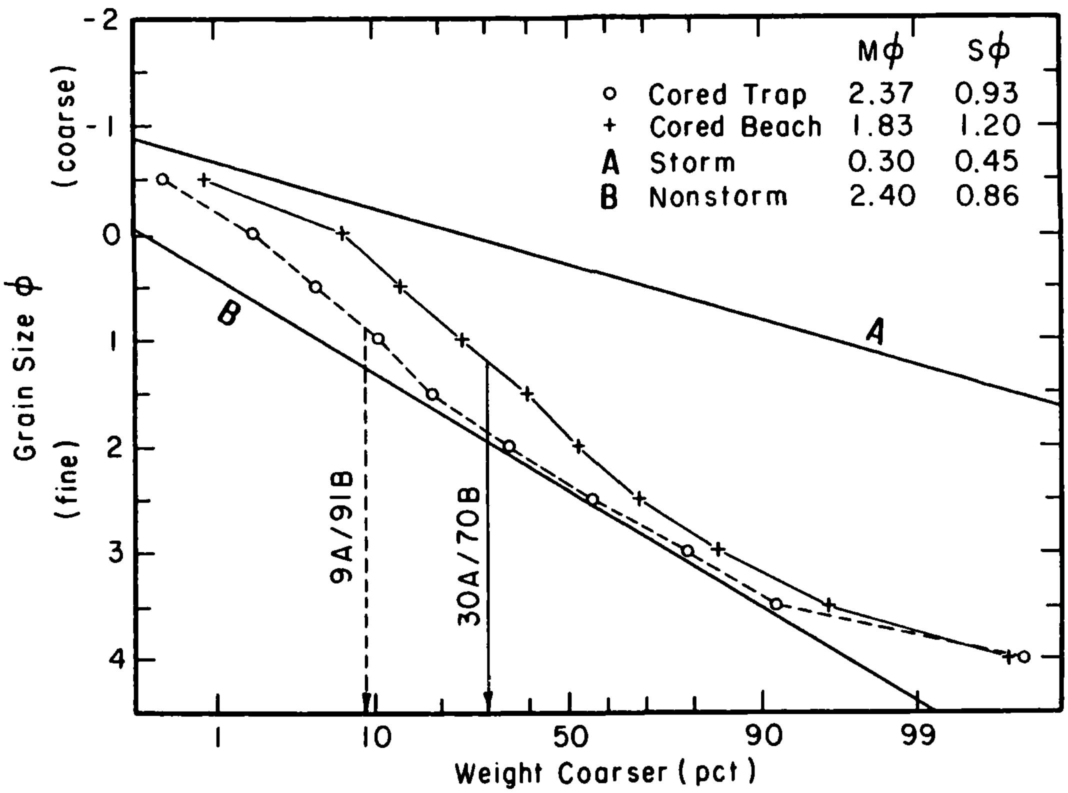


Figure 10. Polymodal cumulative probability curve for cored trap and beach sediments shown with partitioned lognormal subpopulations (A and B) and inflection points (arrow) showing position of subpopulation overlap (after Ashley, 1978).

The two straight-line normal distributions (Fig. 10) are identified with sediments deposited during storm (A) and nonstorm (B) conditions. Mixing these populations in the ratios of 9A:91B and 30A:70B provides very close approximations to the observed cored trap and cored beach composites, respectively. The ratios themselves reflect the graphically determined inflection points of the cored composites which is a somewhat arbitrary determination method. Nevertheless, repeating the technique using these composites, as well as the beach and trap grab composites, range composites, and transect grain-size composites still results in the identification of two normal sediment populations with mean and sorting values quite close to those shown as storm and nonstorm in Figure 10. The conclusions drawn here are that (a) the coarse component A (storm?) makes up about three times as much of the beach sediments as it does the cored trap sediments, and that (b) high energy transport conditions, intense enough to transport coarse population A, were required for only about 10 percent of the trap fill. These results also support the earlier conclusion that coring is probably not the best method for assessing native beach sediment texture because the data collected are easily biased by the storm history of the beach.

VI. BEACH-FILL CONSIDERATIONS

1. Beach-Fill Models.

The Channel Islands sand trap is used to interrupt longshore transport in order to maintain the entrance channel to the harbor, and the accumulated sands are periodically bypassed downcoast as beach nourishment. The data presented in Table 5 can be used as one method to assess the impact on beach-fill design by the textural modifications caused by the trap structure and trap-filling process. In this case, the native beach is the updrift beach rather than the downdrift beach that normally would receive the bypassed sand. The downcoast beach is similar in many ways but it has been nourished frequently and adequate textural data for describing its "native sediments" were unavailable for this analysis.

The effect of the coarse, cored native composite is immediately evident in Table 5. This cored sand was both coarser and more poorly sorted than the borrow and this combination resulted in a predicted overfill requirement of 150 percent. An even higher overfill estimate would result if the cored native were compared with the even finer grab-sampled fill. Overfill requirements of 10 and 5 percent are estimated when the surface-sampled native beach sands are compared to grab and core trap fill, respectively. These estimates are more in keeping with known processes of trap filling during which the offshore breakwater reduced transport energies in the trap, resulting in a fill that is slightly finer than the native beach sediments. Again, Table 5 demonstrates the possible pitfalls or bias produced by core sampling beach sediments.

2. Dredging and Sediment Bypassing.

The maps of trap-fill sediment texture (Figs. 5 and 6) provide a way to evaluate different dredge and bypass operational plans. In a sense, the trapped sediments can be likened to an ore body which is periodically mined (dredged) and whose richness, as measured by texture, varies within the trap. These variations in texture in the Channel Islands trap are very much like those for the native beach and are oriented essentially shore-normal with sediments

Table 5. Beach-fill model comparisons.

Source	$M\phi$	$S\phi$	R_A[1]	R_J[1]
Native 1 - Beach (core samples)	1.83	1.20	2.50[2]	1.80
Borrow 1 - Trap (core samples)	2.37	0.93		
Native 2 - Beach (grab samples)	2.34	0.83	1.10[3]	1.20
Borrow 2 - Trap (grap samples)	2.47	0.84		
Native 3 - Beach (grab samples)	2.34	0.83	1.05[4]	0.80
Borrow 3 - Trap (core samples)	2.37	0.93		

[1]Adjusted SPM (R_A) and renourishment (R_J) fill factors (James, 1975).

[2]Suggesting a 150-percent overfill requirement.

[3]Suggesting a 10-percent overfill requirement.

[4]Suggesting a 5-percent overfill requirement.

becoming progressively finer and better sorted along the profiles from the beach toward the offshore. Other significant textural patterns such as shore-parallel trends or trends that vary with depth within the trapped sand were not present.

There are several ways that the textural trends described above might be used. For example, the finer sands located offshore could be dredged first to serve as the core of a beach fill which could then be covered and protected by the coarser and more stable nearshore sands. To achieve this configuration, the dredge would be moved through the trap, parallel to the beach with each new cut located shoreward of the previous cut. Another dredging scheme might call for shore-normal cuts in order to achieve a more homogeneous beach-fill sediment by mixing offshore (finer) and nearshore (coarser) trapped sediments. Or, a selective dredge and fill plan might be used so that coarser sand is placed where erosion has been greatest on the downcoast beach and the finer sand where the beach has been more stable. The points to be repeated here are that textural patterns within this trap are both simple and significant, and that these patterns could be easily exploited to plan an efficient and successful dredge and bypass operation.

VII. CONCLUSIONS

1. The Channel Islands sediment trap functioned as designed by trapping the bulk of littoral drift sediments.

2. Filling of the trap was generally slower than for earlier dredge and fill cycles. Filling was in response to a series of "pulses" of updrift sediment influx whose intensity and duration did increase toward the end of the study.

3. Sediment generally entered the trap along the nearshore with finer fractions then distributed offshore resulting in final textural patterns similar to those characterizing an open coastline.

4. Textural patterns of the trapped sediments indicate that depositional processes in the trap were sufficient to transport grain sizes present in native beach sediments.

5. Both core sampling and surface grab sampling through time proved to be adequate for describing the composite texture of trapped sediments. Both methods work because of the rather simple filling history of the trap.

6. Grab sampling through time appears to be the best sampling technique for characterizing native beach sands. Core sampling proved inadequate for describing beach sediments because abundant storm-lag deposits bias sediment texture toward a too coarse and too poorly sorted beach composite.

7. Textural comparisons of beach and trap sediments, using techniques for polymodal interpretation, suggest that extreme storm conditions are needed to transport only about 10 percent of the sediments deposited in the trap.

8. Beach-fill calculation comparisons also indicate core sampling of native beach sediments to be an easily biased and potentially misleading data source. Composite grain-size distributions for beaches based on coring will probably produce conservative beach-fill model estimates because of the importance of storm-lag sediments concentrated in the nearshore sediment column.

9. Significant patterns of sediment texture exist within the trap which might be utilized during maintenance dredging to affect the performance of the downcoast beach nourishment project.

LITERATURE CITED

ASHLEY, G.M., "Interpretation of Polymodal Sediments," *Journal of Geology*, Vol. 84, No. 4, 1978, pp. 411-421.

BALSILLIE, J.H., "Surf Observations and Longshore Current Prediction," TM 58, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Nov. 1975.

BRUNO, R.O., and GABLE, C.G., "Longshore Transport at a Littoral Barrier," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Honolulu, Hawaii, 1976, pp. 1203-1222.

BRUNO, R.O., et al., "Longshore Sand Transport Study at Channel Islands Harbor, California," TP 81-2, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Apr. 1981.

HERRON, W.J., and HARRIS, R.L., "Littoral Bypassing and Beach Restoration in the Vicinity of Port Hueneme, California," *Proceedings of the 10th Conference on Coastal Engineering*, American Society of Civil Engineers, Tokyo, Japan, 1966, pp. 651-675.

HOBSON, R.D., "Review of Design Elements for Beach-Fill Evaluation," TP 77-6, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., June 1977.

HOBSON, R.D., "Definition and Use of the Phi Grade Scale," CETA 79-7, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Nov. 1979.

JAMES, W.R., "Techniques in Evaluating Suitability of Borrow Material for Beach Nourishment," TM 60, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Dec. 1975.

KRUMBEIN, W.C., and GRAYBILL, F.A., *An Introduction to Statistical Models in Geology*, McGraw-Hill Book Co., New York, 1965.

SINCLAIR, A.J., "Selection of Threshold Values in Geochemical Data Using Probability Graphs," *Journal of Geochemical Exploration*, No. 3, 1973, pp. 129-149.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

APPENDIX

PHI MEAN AND PHI SORTING VALUES FOR CORE SEDIMENT SAMPLES

Transect 170

Core length (m)	Core 1 Top elev[1] 2.44 m		Core 5 Top elev[1] 2.74 m		Core 9 Top elev[1] 3.35 m		Core 13 Top elev[1] 3.05 m		Core 17 Top elev[1] 0.00 m	
	Mϕ	Sϕ	Mϕ	Sϕ	Mϕ	Sϕ	Mϕ	Sϕ	Mϕ	Sϕ
0										
	2.17	0.56	1.47	0.62	1.07	0.82	1.65	0.68	1.69	0.82
	2.13	0.73	1.44	0.76	1.43	0.69	1.47	0.71	1.46	0.86
	2.18	0.80	1.31	0.78	1.13	0.63	1.58	0.87	1.77	0.90
1										
	1.77	1.67	1.23	0.67	1.07	0.71	1.27	1.05	2.03	0.64
	1.73	0.67	1.24	0.79	1.04	0.91	0.57	0.99	1.52	0.84
	1.41	1.16	0.85	0.94	1.17	0.94	0.99	0.78	1.40	0.75
2										
	1.19	1.05	1.10	0.85	1.25	0.99	1.44	0.89	1.37	0.68
	0.82	1.17	1.21	0.92	1.64	0.83	1.75	0.84	1.88	0.68
	1.30	1.26	2.21	0.95	1.25	1.07	1.48	0.84	1.76	0.62
3										
	2.12	1.03	1.71	0.67	1.81	0.69	1.24	0.95		
	2.38	1.43	1.34	0.96			1.24	0.95		
	2.56	0.63	2.06	1.03						
4										
	2.41	0.75	1.73	1.00						
	1.85	0.92	1.74	1.01						
	1.95	0.51	2.12	0.96						
5										
	2.10	0.70	1.95	1.09						
	2.50	0.73	1.87	0.95						
	2.12	0.81	1.74	0.73						
6										
	2.02	0.70	2.19	0.64						
	1.79	0.97	2.23	0.55						
	2.07	0.97	2.26	0.63						
7										
			2.44	0.86						
			2.10	0.60						
			2.46	0.75						
8										
			2.37	0.89						
			2.45	0.98						
			2.68	0.66						
9										

[1]Elevation of top of core relative to MLLW datum.

Transect 260

Core length (m)	Core 2 Top elev[1] -3.35 m Mφ	Sφ	Core 6 Top elev[1] -0.30 m Mφ	Sφ	Core 10 Top elev[1] 0.61 m Mφ	Sφ	Core 14 Top elev[1] 0.61 m Mφ	Sφ	Core 18 Top elev[1] -1.83 m Mφ	Sφ
0										
	2.84	0.61	2.28	0.61	2.16	0.76	2.07	0.78	2.19	0.78
	2.72	0.56	2.23	0.53	1.26	0.74	1.94	0.74	2.40	0.70
	2.63	0.51	2.18	0.77	2.47	0.70	1.84	0.78	2.43	0.82
1										
	2.76	0.59	2.22	0.58	2.15	0.90	1.38	0.89		
	2.89	0.52	2.45	0.81	2.22	0.65	1.55	0.85		
	2.95	0.57	2.40	0.75	1.65	0.86	1.70	0.90		
2										
	2.57	0.83	2.32	0.76	2.05	0.89	1.85	1.01		
	2.55	0.62	2.27	0.77	2.61	0.50	1.71	0.81		
	2.37	0.90	2.23	0.58	2.59	0.56	2.03	0.70		
3										
			2.07	0.85	2.29	0.75	1.82	0.85		
			1.98	0.98	2.01	0.80	1.99	0.79		
			1.95	1.02	1.94	0.67	1.71	0.74		
4										
			2.45	0.67	1.87	0.66				
			2.54	0.63	2.09	0.81				
			2.73	0.76	2.13	0.77				
5										
			2.80	0.59						
			2.43	0.62						
			2.90	0.53						
6										
			2.84	0.63						
			2.96	0.60						
			2.62	0.53						
7										
			2.25	0.68						
			2.49	0.74						
			2.44	0.70						
8										
			2.69	0.60						

[1]Elevation of top of core relative to MLLW datum.

Transect 350

Core length (m)	Core 3 Top elev[1] -5.18 m Mφ	Sφ	Core 7 Top elev[1] -4.26 m Mφ	Sφ	Core 11 Top elev[1] -3.65 m Mφ	Sφ	Core 15 Top elev[1] -3.05 m Mφ	Sφ	Core 19 Top elev[1] -2.43 m[2] Mφ	Sφ
0										
	2.78	0.58	3.00	0.63	2.69	0.72	2.68	0.60	2.26	0.69
	2.58	0.59	2.41	0.46	2.58	0.54	2.57	0.67	2.26	0.74
	2.59	0.40	2.49	0.48	2.56	0.63	2.59	0.70	2.03	0.29
1										
	2.95	0.54	2.73	0.50	2.76	0.57	2.54	0.72	2.40	0.56
	2.47	0.49	2.80	0.54	2.57	0.44	2.37	0.69	2.39	0.59
	2.69	0.69	2.68	0.47	2.50	0.57	2.16	0.79	2.60	0.75
2										
	2.77	0.54	2.46	0.62	2.77	0.56	2.14	0.76	2.74	0.58
			2.54	0.50	2.79	0.72	2.33	0.68	2.62	0.64
			2.43	0.49	2.92	0.57	2.54	0.66	2.24	1.00
3										
			2.45	0.53	3.00	0.77	2.62	0.55	2.38	0.57
			2.47	0.62	3.03	0.56	2.59	0.59	2.36	0.58
			2.93	0.71	2.87	0.52	2.60	0.70	2.33	0.56
4										
			2.98	0.49	2.76	0.56	2.52	0.87	2.53	0.49
			2.86	0.56	2.71	0.60	2.48	0.78	2.47	0.48
			2.65	0.48	2.73	0.87	2.73	0.60	2.67	0.58
5										
			2.61	0.54			2.61	0.57	2.33	0.80
			2.78	0.52			2.66	0.61	2.22	0.93
			3.05	0.86			2.54	0.74	2.40	0.60
6										
							2.67	0.65	2.43	0.73
							2.63	0.53	2.53	0.61
							2.53	0.53	2.17	0.90
7										
							2.81	0.69	2.31	0.95
							2.75	0.75	2.36	0.88
							2.83	0.59	2.43	0.75

Transect 440

Core length (m)	Core 4 Top elev[1] -8.23 m Mφ	Sφ	Core 8 Top elev[1] -9.44 m Mφ	Sφ	Core 12 Top elev[1] -10.63 m Mφ	Sφ	Core 16 Top elev[1] -9.45 m Mφ	Sφ	Core 20 Top elev[1] -9.45 m Mφ	Sφ
0										
	2.49	0.45	2.71	0.79	2.76	0.59	2.85	0.77	3.05	0.75
	2.62	0.58	2.87	0.68	3.00	0.66	2.97	0.57	3.15	0.70
	2.87	0.57	3.03	0.62	3.11	0.58	3.05	0.86	3.15	0.64
1										
	2.94	0.64	2.74	0.88	2.99	0.87				
	2.92	0.62								
	2.72	0.51								
2										

[1]Elevation of top of core relative to MLLW datum.

[2]Location where core length is less than active thickness.

Native Beach

Core length (m)	Core 21 Top elev[1] 4.26 m Mϕ	Sϕ	Core 22 Top elev[1] 2.43 m Mϕ	Sϕ	Core 23 Top elev[1] 0.00 m Mϕ	Sϕ	Core 24 Top elev[1] -1.83 m Mϕ	Sϕ	Core 25 Top elev[1] -3.66 m Mϕ	Sϕ
0										
	1.16	0.71	1.44	0.67	1.73	0.87	2.40	0.70	2.65	0.53
	1.31	0.64	1.52	0.67	1.51	0.93	2.23	0.82	2.77	0.47
	1.32	0.72	1.02	0.85	1.21	1.12	2.48	0.68	1.84	1.17
1										
	0.96	1.02	1.37	0.73	1.61	1.06	2.36	0.53		
			1.44	0.81	1.80	0.77				
			1.79	0.56	1.02	1.11				
2										

Native Beach

Core length (m)	Core 26 Top elev[1] -6.40 m Mϕ	Sϕ	Core 27 Top elev[1] -7.32 m Mϕ	Sϕ	Core 28 Top elev[1] -8.84 m Mϕ	Sϕ
0						
	2.74	0.60	2.92	0.70	3.05	0.59
			2.86	0.88	2.87	0.76
1						

[1]Elevation of top of core relative to MLLW datum.

Hobson, R.D.

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