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Final Report for Field Studies of Nearshore Sedimentary Structures

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Final report

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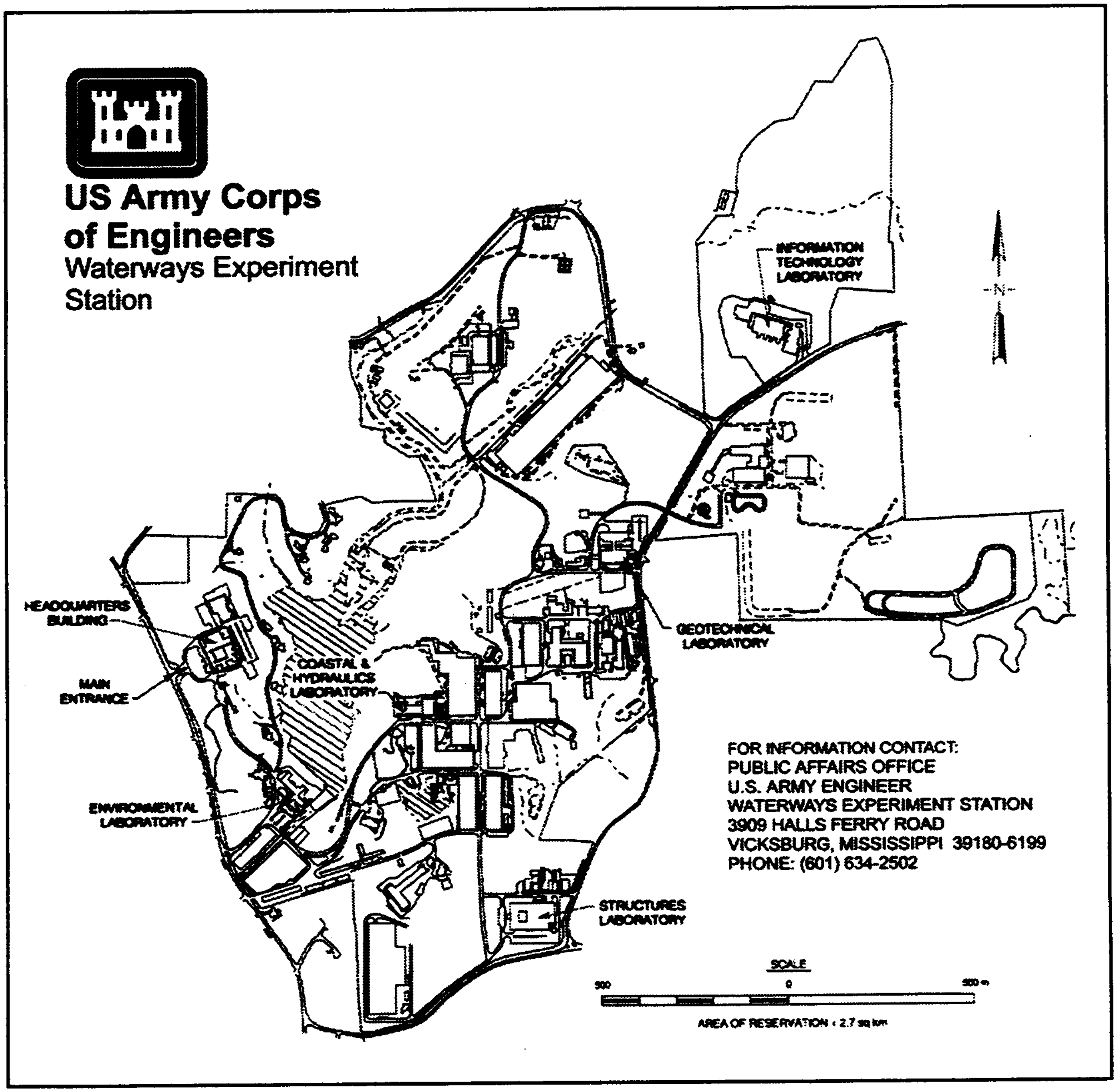

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
inches	0.0254	meters

Preface

The investigation summarized in this report was conducted by the U.S. Army Engineer Waterways Experiment Station's (WES's) Coastal and Hydraulics Laboratory (C&HL) and was selected for study and funded by the Coastal Sedimentation and Dredging Program. The Program Manager is Carolyn Holmes. This program is sponsored by Headquarters, U.S. Army Corps of Engineers (HQUSACE). The HQUSACE Program Monitors are Messrs. John H. Lockhart, Jr., Charles Chesnutt, and Barry W. Holliday.

Work was performed under the general supervision of Mr. William A. Birkemeier, Chief, Field Research Facility (FRF), C&HL; Mr. Thomas W. Richardson, Chief, Engineering Development Division, C&HL; Dr. James R. Houston, Director, C&HL.

The report was prepared by Dr. Thomas G. Drake of North Carolina State University, Raleigh, NC. Funding for this research was provided by CH&L (Contract DACW39-94-0037: Field Studies of Nearshore Sedimentary Structures). The vibracores used in this study were collected through the efforts of many individuals including Keil Schmid, Srinath Alapati, Mark Lampe, Mason Cox, Doug Dorman, and J.B. Smith. Technical and logistical support at the FRF was generously provided by Eugene W. Bichner, Brian Scarborough, and Charles R. Townsend, Mike Leffler, and Bill Grogg. William A. Birkemeier, Chief, FRF, provided supervisory and technical support, as well as much appreciated advice concerning field operations. Beach and nearshore survey data for documenting profile dynamics at the FRF site were provided by C&HL through the courtesy of William A. Birkemeier.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Introduction

The research described herein is a part of the Duck94 Nearshore Processes Field Experiment, a multi-disciplinary study that took place during the summer and fall months of 1994 at the U.S. Army Engineer Field Research Facility (FRF) at Duck, North Carolina. The work comprises reconnaissance field studies seeking to develop tools for hydrodynamic and bathymetric interpretation of nearshore sedimentary structures, using as primary data sediment cores taken in close proximity to fluid-motion and bed-elevation measurements. This report conveys the following products listed in contract DACW39-94-K-0037, as modified 29 March 1994:

> Sedimentological data from cores obtained by Drake will be maintained in the form of core logs, which will record the time, location and orientation of each sample, and a description of sedimentary structures obtained by visual inspection. The following ancillary data will be provided by Scripps Institution of Oceanography (SIO) investigators R.T. Guza, S. Elgar, and E. Gallagher for cores obtained by Drake which are located within 20m of the SIO cross-shore instrument transect: mean water depth, mean wave height, mean cross-shore and mean alongshore fluid velocity and net change in bed elevation at the nearest SIO sensor, where the time interval for net change in bed elevation and averaging all quantities will be determined by the principal investigator. The ancillary SIO data will be provided under the Duck94 data sharing policy of no unapproved dissemination to third parties. Relationships between sedimentary features observed in the cores and fluid motion and bed elevation studies will be explored in collaborative interaction with SIO, NPS and/or FRF investigators, with the aim of producing one or more articles for publication in refereed scientific journals. A final report covering the period of support and including the core logs will be provided at the end of FY95. No provision is made in this proposal for preservation or storage of cores.

A no-cost extension of the original contract through 31 March 1996 was provided to accommodate additional analysis of ancillary data provided by SIO collaborators.

Synopsis of Results

Few studies of sedimentary structures in the nearshore have been undertaken (e.g., Clifton *et al.*, 1971; Hunter *et al.*, 1979; Greenwood and Osborne, 1991) and none have had the benefit of the substantial supporting studies conducted during the Duck '94 experiment, in particular, a cross-shore transect of instruments designed to provide measurements of water depth, bed elevation, and cross- and alongshore components of nearbed water velocity at a frequency of 2 Hz for the duration of the Duck '94 experiment. Observations of these fundamental fluid-dynamic quantities, provided by investigators R.T. Guza and S. Elgar of the Center for Coastal Studies, Scripps Institution of Oceanography, University of California at San Diego, form the basis for relating sedimentary structures from sediment cores obtained using the FRF's Coastal Research Amphibious Buggy (CRAB). Analyses of the cores were undertaken both during the course of the experiment and afterwards at North Carolina State University.

The principal findings of this investigation are the following:

- Sedimentary structures observed in the cores, in particular, bedding planes or other evidence of stratification, are generally rather poorly correlated with synthetic stratigraphies generated from sonic altimeter observations of bed elevation. In a few particular cases, however, the correlation between structures observed in cores and sonic altimeter observations is good, and may offer useful means for using structures from cores to retrodict the wave climate responsible for their formation, or vice-versa. Techniques for generation of synthetic stratigraphies and special cases of interest are discussed in detail below.
- Alongshore variation in sedimentary structures from cores obtained at the same nominal cross-shore location may be substantial, which carries the implication that even apparently two-dimensional nearshore environments (such as that at the Duck study site (Stauble, 1992)) may not be adequately sampled by a single or even several cross-shore transects.
- Presence of estuarine mud near the present seabed in several cores suggests that sediment supply in the vicinity of the Field Research Facility may be limited, and that relatively non-erodable substrate may crop out in the surfzone. That the underlying geology may strongly influence shoreface evolution along the Outer Banks has been previously suggested (Riggs *et al.*, 1995), but extant predictive models for bathymetric evolution uniformly assume sufficient sediment supply at all times. The possibility of insufficient supply and its effects

must be addressed in future studies.

- Cores extracted from the crest of a newly-deposited bar formed entirely during the course of the Duck '94 experiment show unequivocally that offshore bar migration occurred by the onshore migration of megaripples from deep water onto the offshore side of the bar, while unknown processes eroded the onshore side of the bar. Evidence for megaripple-induced bar migration is in the form of onshore-dipping cross-bedded sand layers preserved in the cores, which can only result from grains avalanching down the slipface of an onshore-migrating bedform. Much ancillary evidence for the presence of such bedforms exists, but the only unequivocal evidence of the direction of their migration is found in oriented bar-crest cores. This result is unexpected, since hydrodynamic data (e.g. Gallagher, 1996) indicate pervasive offshore water velocities over most of the vertical water column, and models for sediment transport (e.g. Bowen, 1980; Bailard, 1981, hereafter called the Bowen/Bailard model) which use the velocity data predict both net offshore sediment transport and offshore bar migration. Our data show that, while *offshore* flow higher in the water column most likely transported suspended sediment offshore over the bar crest, nearbed velocities must have driven megaripple migration in the *onshore* direction. Such observations 1) call into question the efficacy of the Bailard/Bowen model, and 2) point to the need for considerably more work on fundamental sediment-transport processes, in particular, the mechanics of megaripple migration.
- Finally, logistical difficulties associated with surfzone coring studies are considerable. For the very limited set of conditions explored during the course of this reconnaissance study, the predictive value of most of the cores obtained is equivocal. On the other hand, we now know the conditions under which cores are likely to obtain extremely useful information that cannot be obtained by direct (and expensive) surfzone observation of the usual hydrodynamic variables, in particular the near-bed fluid velocity. The evidence for megaripple-induced bar migration offered by sedimentary structures in the cores is immensely valuable, and exists nowhere else in the collective Duck '94 dataset.

The body of this report consists of a description of coring and analysis techniques, an overview of sedimentary structures observed in the cores and their significance, and a detailed examination of some particularly significant cores. Supporting information includes a table of cores taken during the experiment, including relevant hydrodynamic quantities from SIO investigators, detailed visual descriptions of most of the cores and descriptions of radiographs which were obtained for some of the cores. Some of the information contained herein was presented by Mr. J.B. Smith, Contract Officer's Representative for this contract, at the Geological Society of America Annual Meeting in New Orleans, Louisiana, November, 1995 (Smith *et al.*, 1995). A videotape showing an animated visualization of a typical synthetic stratigraphy generated from bed-elevation time series is available from the author of this report.

Methods and Analysis

Short vibracores obtained using the FRF's CRAB as a coring platform provided essentially all the sedimentological information for this study. Attempts to use small boxcores in the surfzone proved unsatisfactory, for one or more of the following reasons: poor or hazardous diving conditions; including large waves in shallow water, strong currents, poor visibility and concomitant difficulty in establishing the location and orientation of the core; box-core equipment failure due to compacted, fine-grained bottom sediment. Vibracores were obtained after several significant sedimentologic events using the CRAB. Standard techniques were used to obtain cores in three-inch-diameter aluminum tubes; sample location and orientation were determined from CRAB instrumentation. Core locations are reported in meters in the FRF coordinate system, and elevation of the seabed (or top of the core) is referenced to NGVD. The nominal resolution in all three coordinates is about 10 cm; for the highly irregular bathymetry associated with megaripples the bottom elevation may vary by 30 cm or more from the reported value, due to the location of the survey reference point on the top of the CRAB, rather than at the seabed. The coarse nature of the bed material precluded the effective use of a core-catcher, and some cores of coarse sand and gravel were disturbed during the coring and/or extraction procedure. Such disturbances are noted in the core logs; and in general, the uppermost 10 cm to 25 cm of the cores do not yield reliable sedimentary structure information.

All cores were cut longitudinally such that the cutting plane trended in the on-offshore direction, for the purpose of revealing cross-stratification of on-offshore migrating bedforms. This choice of orientation effectively biases the observations, as stratification due to alongshore migrating bedforms may not be evident in cores cut as described above. Once cut, cores were logged visually by Mr. Keil Schmid (Table 1 and Appendix A). Selected cores were slabbed for x-ray radiography using conventional techniques (Appendix B). Particular care was made to distinguish erosional contacts and their orientation in the cores, as these are the primary indicators of sediment-transport mechanisms.

Hydrodynamic data was obtained from SIO investigators R.T. Guza and S. Elgar for sensors located on a cross-shore transect extending from the swash zone to about 900 m offshore. Figure 1 shows the location of the SIO instrument transect and the vibracores taken during this

Table 1. List of all vibracores collected at Duck NC Field Research Facility during Duck '94

Tom Drake, J. Bailey Smith, Keil Schmid, Srinath Alapati

			Core Location, FRF coords			Data provided for cores within 20 m of SIO transect; Weighted by depositional thickness of sedimentary strata				
Core No.	Date	Days after July 20th	Longshore Y (m)	Cross-shore X(m)	Elev NGVD (m)	Net deposition (cm)	U (+ onshore) (cm/s)	V (+ to south) (cm/s)	Significant Wave height (cm)	Current Direction (0=north)
1	9-Aug-94	20	998.8	313.9	-3.42					
2	9-Aug-94	20	998.8	311.8	-3.40					
3	9-Aug-94	20	1000.7	160.3	-1.90					
4	11-Aug-94	22	992.7	183.2	-1.52					
5	11-Aug-94	22	991.8	206.0	-1.80					
6	11-Aug-94	22	940.9	169.8	-1.40		no sensor data			
7	11-Aug-94	22	941.5	207.9	-1.77	2.50	no hydrodynamic data before 25.96 days after 20 July 1994			
8	11-Aug-94	22	960.7	169.2	-1.32					
9	18-Aug-94	29	940.0	135.0	-0.26		no sensor data			
10	18-Aug-94	29	940.0	190.2	-1.69		no sensor data			
11	18-Aug-94	29	940.0	220.2	-2.07	9.99	-2.30	-17.50	84.10	7
12	18-Aug-94	29	940.0	240.6	-2.35	63.75	-5.90	-19.50	42.70	17
13	19-Aug-94	30	991.1	138.6	-0.52					
14	19-Aug-94	30	991.0	146.6	-1.08					
15	19-Aug-94	30	992.2	219.9	-1.74					
16	19-Aug-94	30	992.6	240.8	-2.08					
17	19-Aug-94	30	992.6	242.4	-2.23					
18	19-Aug-94	30	960.0	220.7	-1.86					
19	19-Aug-94	30	960.5	205.6	-1.83					
20	19-Aug-94	30	961.3	145.7	-0.60					
21	19-Aug-94	30	961.4	135.3	-0.02					
22	19-Aug-94	30	939.4	230.0	-2.10	63.28	-5.50	-16.10	42.30	25
23	19-Aug-94	30	939.5	209.8	-1.86	7.47	no current data		66.80	
24	19-Aug-94	30	940.0	168.8	-1.54		no sensor data			
25	19-Aug-94	30	940.8	145.4	-0.88		no sensor data			
26	19-Aug-94	30	951.7	169.3	-1.55		no sensor data			
27	19-Aug-94	30	950.3	205.8	-1.79	7.47	no current data		66.80	
28	25-Aug-94	36	991.5	599.0	-5.77					
29	25-Aug-94	36	992.3	498.9	-4.91					
30	25-Aug-94	36	992.6	400.0	-4.40					
31	25-Aug-94	36	991.8	346.7	-4.07					

Core No.	Date	Days after July 20th	Longshore Y (m)	Cross-shore X(m)	Elev NGVD (m)	Net deposition (cm)	U (+ onshore) (cm/s)	V (+ to south) (cm/s)	Significant Wave height (cm)	Current Direction (0=north)
32	8-Sep-94	50	939.6	270.2	-2.28	60.73	-29.10	62.10	163.20	155
33	8-Sep-94	50	940.3	260.2	-1.92	60.73	-29.10	62.10	163.20	155
34	8-Sep-94	50	940.6	250.1	-1.80	95.67	-17.70	31.40	82.90	140
35	8-Sep-94	50	940.5	239.9	-1.95	95.67	-17.70	31.40	82.90	140
36	8-Sep-94	50	940.5	230.4	-2.05	13.50	-23.50	0.20	94.00	84
37	8-Sep-94	50	940.3	217.7	-2.05	13.50	-23.50	0.20	94.00	84
38	9-Sep-94	51	940.5	210.3	-2.06	20.00	-1.40	-9.50	63.90	218
39	9-Sep-94	51	940.4	205.1	-2.07	20.00	-1.40	-9.50	63.90	218
40	9-Sep-94	51	939.5	170.4	-2.11		no sensor data			
41	9-Sep-94	51	940.3	152.6	-1.72		no sensor data			
42	9-Sep-94	51	940.2	146.2	-1.13		no sensor data			
43	9-Sep-94	51	960.7	219.9	-2.08					
44	9-Sep-94	51	960.9	250.0	-1.83					
45	9-Sep-94	51	960.2	270.2	-2.21					
46	9-Sep-94	51	960.3	260.1	-1.94					
47	9-Sep-94	51	960.1	239.8	-1.97					
48	9-Sep-94	51	960.0	230.3	-2.07					
49	9-Sep-94	51	960.9	152.9	-1.51					
50	21-Oct-94	93	940.3	370.0	-3.65		no sensor data			
51	21-Oct-94	93	939.6	340.4	-2.98	22.71	-18.40	-2.10	185.30	105
52	21-Oct-94	93	939.8	167.0	-1.64	83.86	-15.30	2.90	116.10	89
53	21-Oct-94	93	939.3	320.0	-2.83	22.71	-18.40	-2.10	185.30	105
54	23-Oct-94	95	939.6	348.1	-2.80		no sensor data			
55	23-Oct-94	95	939.9	330.0	-2.42	102.07	-5.20	-0.50	86.70	156
56	23-Oct-94	95	939.6	309.8	-2.72	102.07	-5.20	-0.50	86.70	156
57	23-Oct-94	95	1006.0	360.2	-3.16					
58	23-Oct-94	95	1005.3	340.2	-2.55					
59	23-Oct-94	95	1006.1	320.2	-2.09					
60	23-Oct-94	95	940.2	160.0	-0.95		no sensor data			
61	23-Oct-94	95	940.3	154.8	-1.19		no sensor data			
62	25-Oct-94	97	940.8	320.7	-2.50	112.00	-4.80	-0.30	83.70	156
63	25-Oct-94	97	940.8	317.5	-2.59	112.00	-4.80	-0.30	83.70	156
64	27-Oct-94	99	940.0	135.1	-0.32		no sensor data			
65	27-Oct-94	99	940.0	119.3	0.42		no data (dry beach)			
66	27-Oct-94	99	940.0	102.9	2.12		no data (dry beach)			

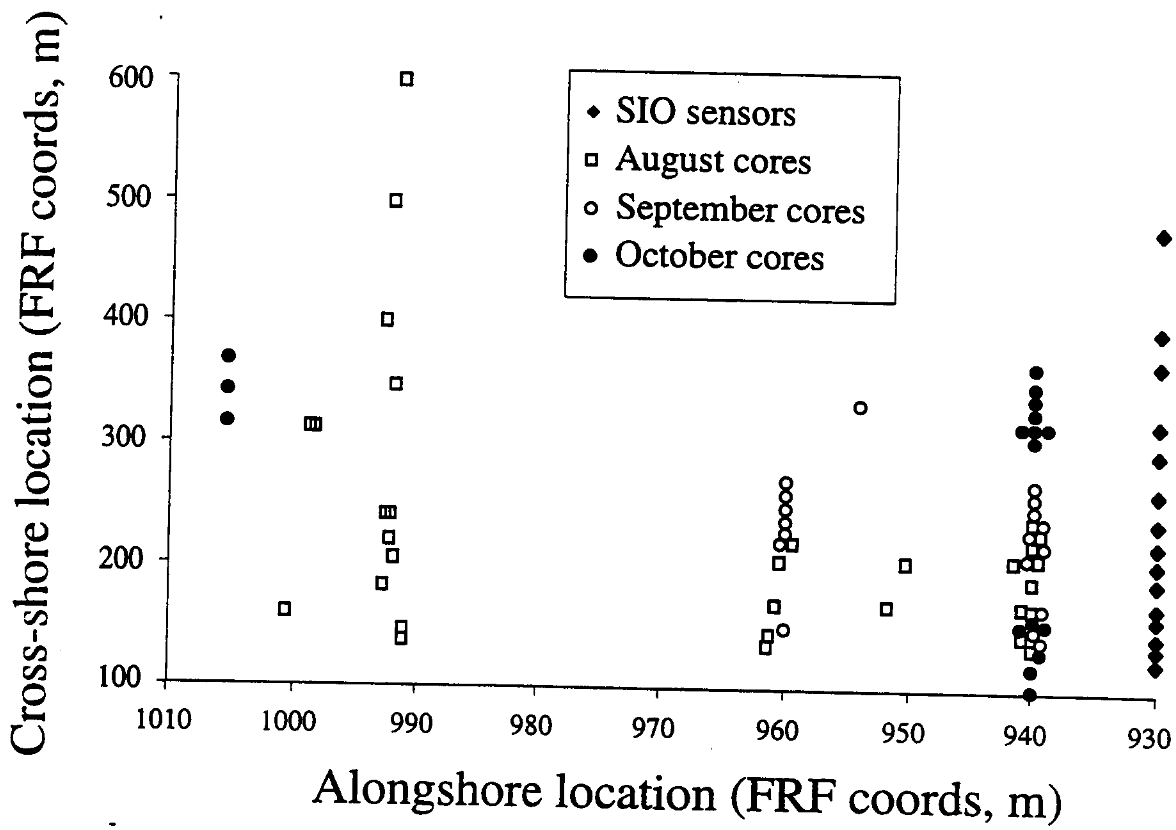

Figure 1. Vibracore locations for three periods during the Duck '94 experiments. August cores were obtained before substantial deposition occurred; September cores were obtained after a brief but intense storm; and October cores were obtained approximately one week after a sustained Nor'easter. Symbols are shifted in the alongshore direction if overlaps would otherwise obscure locations.

study. Table 1 provides details of the vibracore locations and averages of the hydrodynamic data; Table 2 lists the locations of the SIO instrument packages. All hydrodynamic data provided by SIO investigators is subject to the Duck '94 data-sharing agreement, with no distribution to third-party investigators without prior permission. Water-surface elevation, bed-surface elevation, cross- and alongshore components of water velocity were obtained at 2 Hz frequency for most of the Duck '94 experiment. From the 2-Hz data, SIO investigators provided this study with 17-minute averages for water surface elevation, significant wave height, and cross- and alongshore current velocity. The sign convention for water velocities is positive **u** (cm/s) in the onshore direction, and positive **v** (cm/s) to the south.

Time series of bed elevation data are post-processed using a "bottom-finding" algorithm

Table 2. Instrument Locations on the SIO Cross-Shore Transect[1]				
Sensor	**X(m)**	**Y(m)**	**Elevation (m, NGVD)**	**Comment**
p01	830	124.9	0.54	No sonic altimeter or current
p02	830	135.0	-0.31	
p03	830	145.4	-0.92	
p04	830	160.8	-0.58	
p05	830	169.5	-0.63	Sonic heart (array of 7 altimeters)
p23	830	190.2	-1.10	2m-stack, no sonic, 3 current meters
p12	830	205.3	-1.04	
p13	830	220.2	-1.34	
p14	830	240.6	-1.63	
p15	830	264.7	-1.90	
p16	830	295.8	-3.14	No sonic altimeter
p17	830	320.4	-2.93	
p45	830	370.1	-4.31	4m-stack, no sonic, 3 current meters
p18	830	398.4	-3.71	
p19	830	480.3	-4.76	No sonic
p87	830	885.0	-7.79	8m-stack, no sonic, 7 current

[1] Pressure sensors are buried beneath the seabed, and elevation of other sensors varies but is typically less than 0.5 m above the seabed. These elevations correspond to locations established at the initiation of the Duck '94 experiment.

(Gallagher *et al.*, 1996) to provide bottom-location estimates in the surfzone having resolution on the order of ±3 cm about twice per minute. Because the generation of synthetic stratigraphies depends directly on the implementation of the bottom-finding algorithm, a brief description of the algorithm follows:

A histogram having 2-cm-wide distance bins is constructed from 512 bottom samples obtained at 2 Hz. The bin having the highest number of occurrences (excluding distances less than 25 cm) provides a rough estimate of the distance to the seafloor. A second set of histograms having 0.5-cm-wide bins is then calculated for each of eight 32-second-long subintervals of the original 512 samples. These bins are centered ±20 cm of the maximum obtained from the 512-sample histogram. The maxima of the 32-second histograms provide estimates of the distance to the seafloor every 32 s.

Synthetic Stratigraphy

Time series of bed elevations are used to generate "synthetic" stratigraphies for each of the sonic altimeter sensors. In concept, the generation of such stratigraphies is straightforward (Figure 2), but entails numerous assumptions in practice, due to smoothing and filtering of the

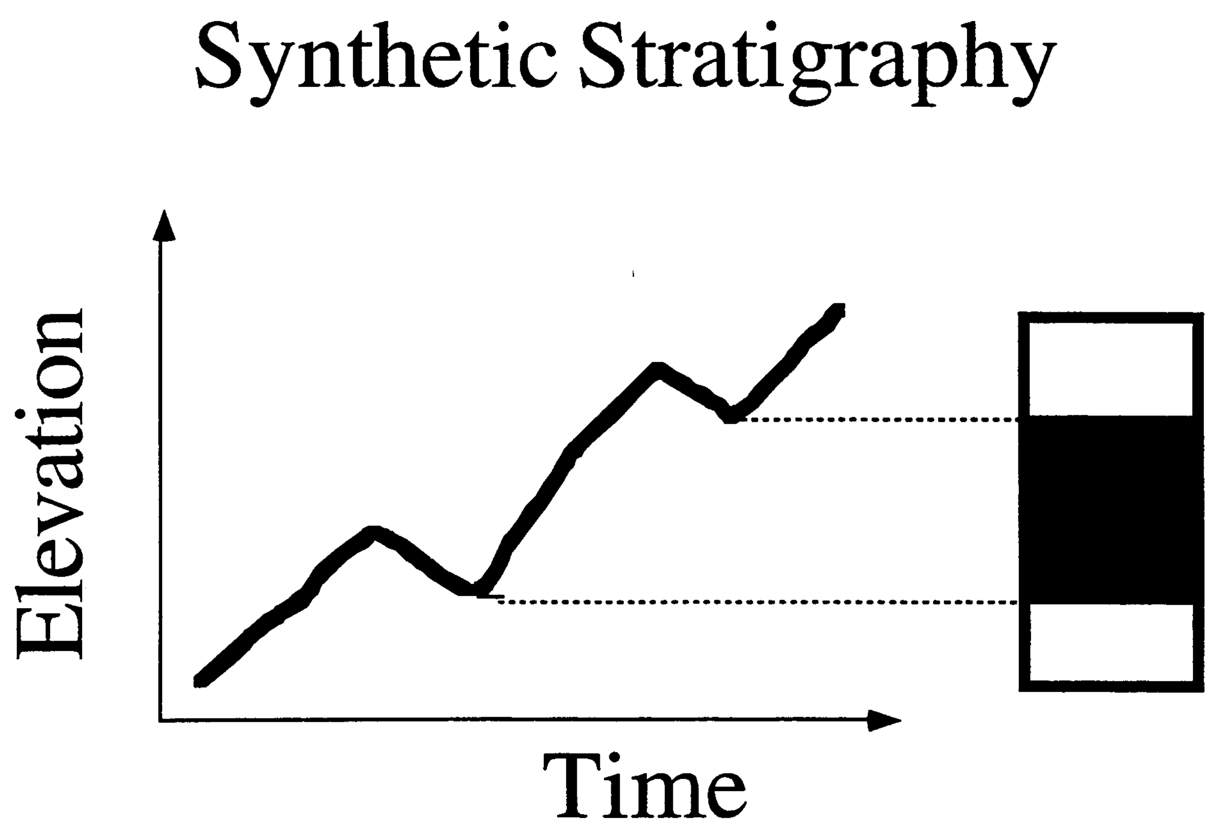

Figure 2. Schematic of synthetic stratigraphy generation using time-series of bed elevation. Alternating black and white bars are hypothetical strata; erosional contacts separate strata.

noisy altimeter data. For each time interval in which the bed elevation remains constant or increases, corresponding to deposition or lack of erosion, a single stratum is produced. The position of the bottom of the stratum corresponds to the start of data acquisition. If the bed elevation decreases, the single stratum is eroded, and the new eroded top of the stratum is thus an unconformity, or depositional hiatus. The stratum may be completely or partially eroded, until deposition is re-initiated and a new stratum is generated. Importantly, there is no information available about the bed history prior to the start of data acquistion; thus sedimentary features only millimeters below the initial bed surface may be minutes or thousands of years old. Likewise, if hundreds of centimeters of deposition are subsequently removed by erosion before a core can be taken, no sedimentary record of the depositional processes can be extracted. Such obvious limitations have and will continue to severely hinder process-oriented sedimentological studies.

Practical problems arise in attempting to determine whether fluctuations in bed-elevation measurements from the sonic altimeters correspond to true fluctuations of the bed surface. Without *a priori* information to guide our choice of filtering parameters, we attempted to optimally select parameters to "best-fit" the number and thickness of strata observed in cores to similar descriptors derived from synthetically generated stratigraphies. Our inability to find such suitable parameters may be attributed to one or more of the following:

Difficulties in visual identification of strata in the cores. Radiographic studies of several selected cores failed to reveal strata in apparently massively-bedded, fine-sand deposits. Such deposits may typify deposition during energetic conditions in the absence of sufficiently rapid bedform migration to create laminae.

Difficulties in evaluating errors in sonic-altimeter data. Altimeter resolution and accuracy are inversely related to some function of the sea-state energy (e.g., significant wave height), while changes in sea-bed elevation are positively correlated significant wave height. Insufficient indepçndent data are available to quantify such errors.

To the extent possible, coring was undertaken when bed elevations were increasing, so that the cores could be expected to contain sediments deposited under known hydrodynamic conditions. In practice, however, logistical constraints including weather and CRAB availability hindered efforts to obtain cores having high information density, and many of the cores contain sediment for which there is no hydrodynamic or bed elevation data. Furthermore, many of the cores were taken much more than 20 m distance from the SIO transect; and these cores are not examined in detail in this report.

Bar Migration Deposits

One of the primary objectives in nearshore research is to determine the sediment-transport mechanisms for bar migration. During the course of the Duck '94 experiment, several bar migration episodes occurred, all of them relatively rapid and in the offshore direction. The typically much slower onshore migration characteristic of spring and summer low-energy conditions was not sampled during this experiment; thus introducing a significant potential bias in the interpretation of nearshore sedimentary deposits. Nevertheless, several cores were taken after a major Nor'easter occurred in mid-October, and analyses of them reveal several features of interest.

Cores 62 and 63 were obtained 25 October 1994, appoximately one week after the cessation of the storm. During the storm the low, linear bar migrated offshore approximately 100 m, and buried the SIO sensors at X=320 m (p17 and associated instruments). The cores are located at the same alongshore position; and core 62 was taken at a cross-shore position X=320.7 m, while core 63 was extracted at X=317.5 m, or approximately 3 m closer to shore. The elevations of the tops of the cores differ by 0.09 m, which corresponds to diver observations of variations in bed surface elevation obtained during the coring procedure. Perhaps surprisingly, these cores exhibit rather distinct sedimentary structures, as shown schematically in Figure 3. An incomplete synthetic stratigraphy shows tantalizing hints about the conditions just preceding and after sensor burial at the height of the storm (Figure 4).

Implications for Mechanisms of Offshore Bar Migration

The uppermost 0.75 to 1 m of each of cores 62 and 63 exhibits well-developed shoreward-dipping crossbeds, which are interpreted as indicative of shoreward bedform migration. Such deposits are essentially unequivocal evidence for *onshore* migration of megaripples, which effected the *offshore* migration of the bar form, perhaps in concert with concurrent deposition of suspended sediment eroded from the onshore side of the bar. Figure 5

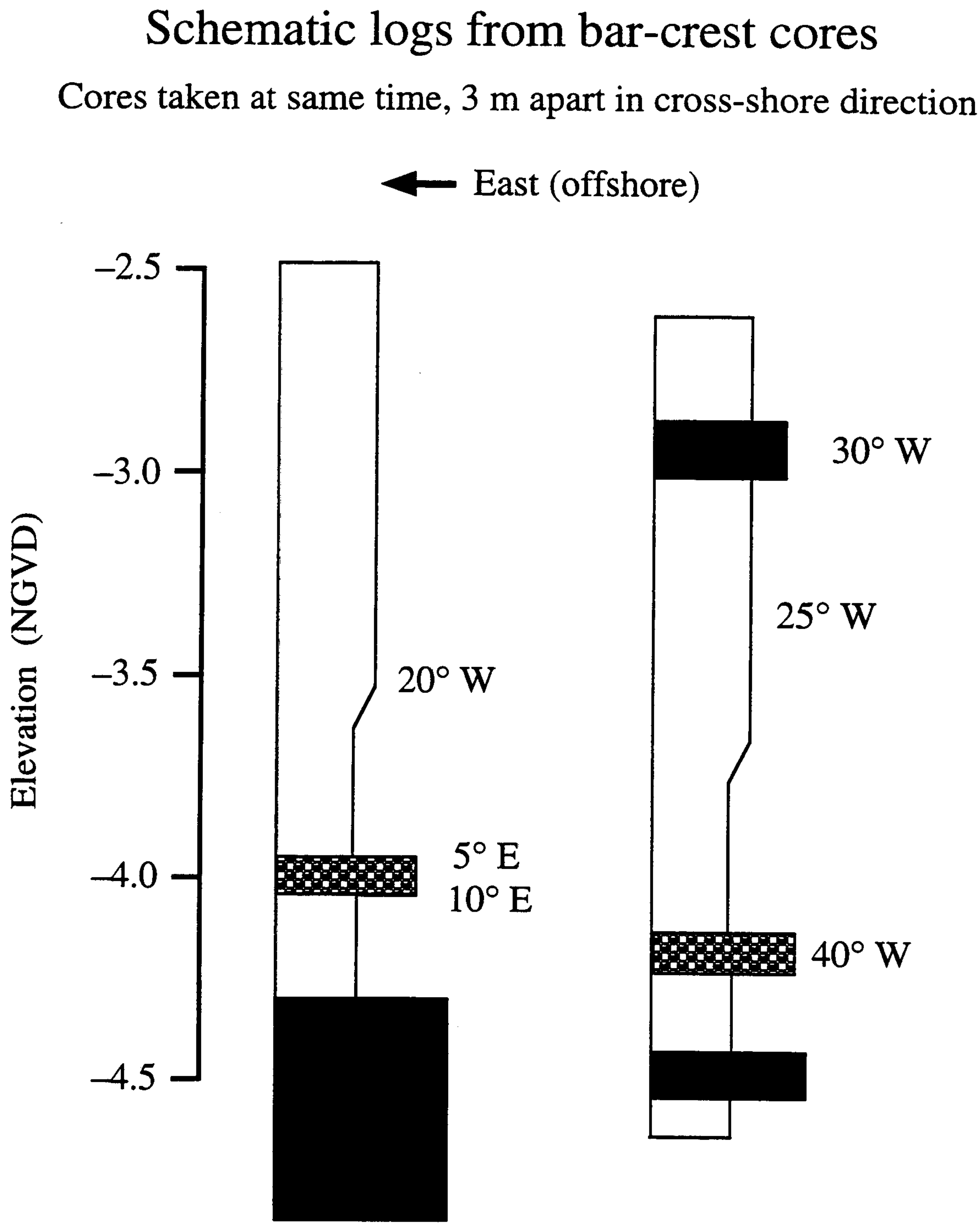

Figure 3. Schematic log showing major sedimentological features of cores 62 (left) and 63 (right), collected 25 October 1994, approximately one week after a major Nor'easter induced offshore-directed bar migration of about 100 m. Despite their relative proximity, the cores are distinctly different, and exhibit cross-strata indicative of bedform migration both on- and offshore.

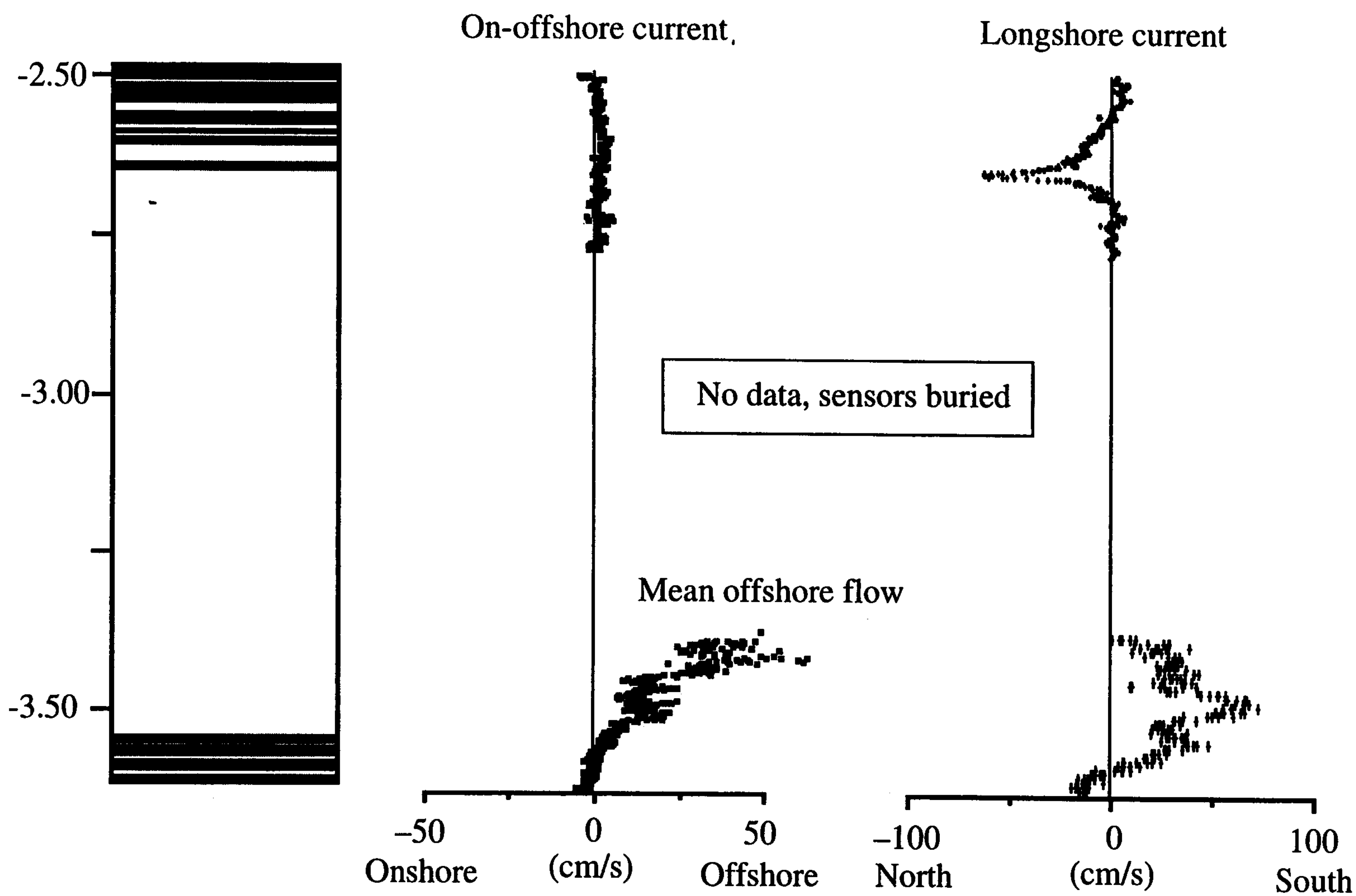

Figure 4. Synthetic stratigraphy and near-bed water velocities from SIO sensors located at cross-shore location X=320 m corresponding to cores 62 and 63. A strong mean offshore flow was measured at this location before instrument burial, and such flows were measured throughout the storm at other cross-shore locations. The uppermost 0.75 to 1 m of cores 62 and 63 exhibit onshore (west) dipping crossbeds, however, which would typically be interpreted as indicative of onshore bedform migration.

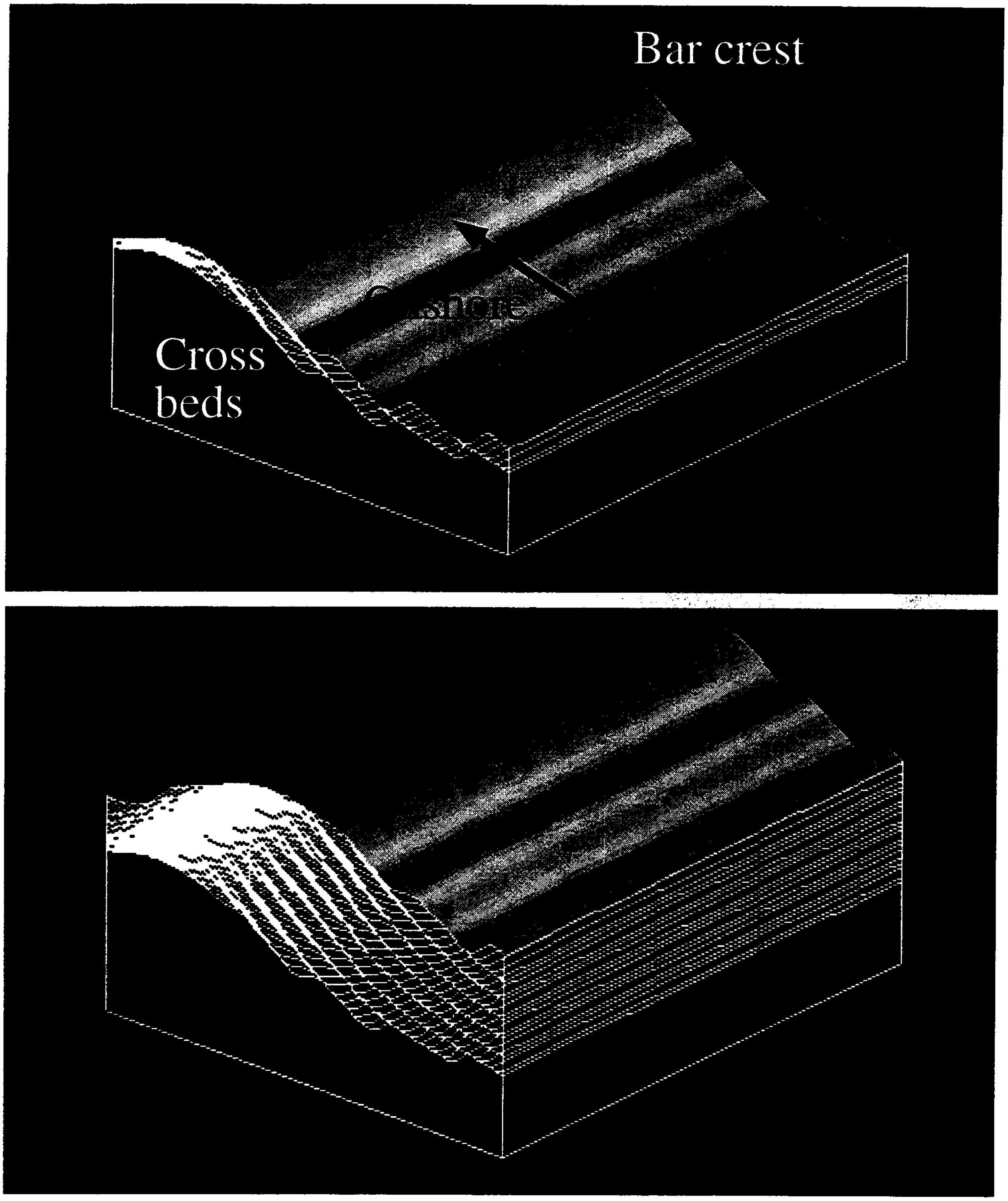

Figure 5. Onshore migration of megaripples deposits sand on the offshore side of the bar crest, which is simultaneously eroding on its onshore side. Top figure shows megaripples at the start of bar migration, and bottom figure shows sequence of cross beds after bar migration. This schematic depiction was created using computer software developed by Dr. David M. Rubin, US Geological Survey (Rubin, 1987).

shows a schematic diagram of the megaripple migration processes inferred to operate on the offshore side of the bar. Figure 6 is a somewhat more speculative picture of one possible scenario for eroding the onshore side of the bar as it migrated offshore; there is considerable evidence for the existence of megaripples migrating alongshore in the bar trough during the bar migration event (Gallagher, 1996; Thornton, personal communication, 1994). Evidence for megaripple-induced bar migration is in the form of onshore-dipping, cross-bedded sand layers preserved in the cores, which can only result from grains avalanching down the slipface of an onshore migrating bedform. Much ancillary evidence for the presence of such bedforms exists (Gallagher, 1996; Thornton, personal communication, 1994), but the only unequivocal evidence of the direction of their migration is found in these oriented bar-crest cores.

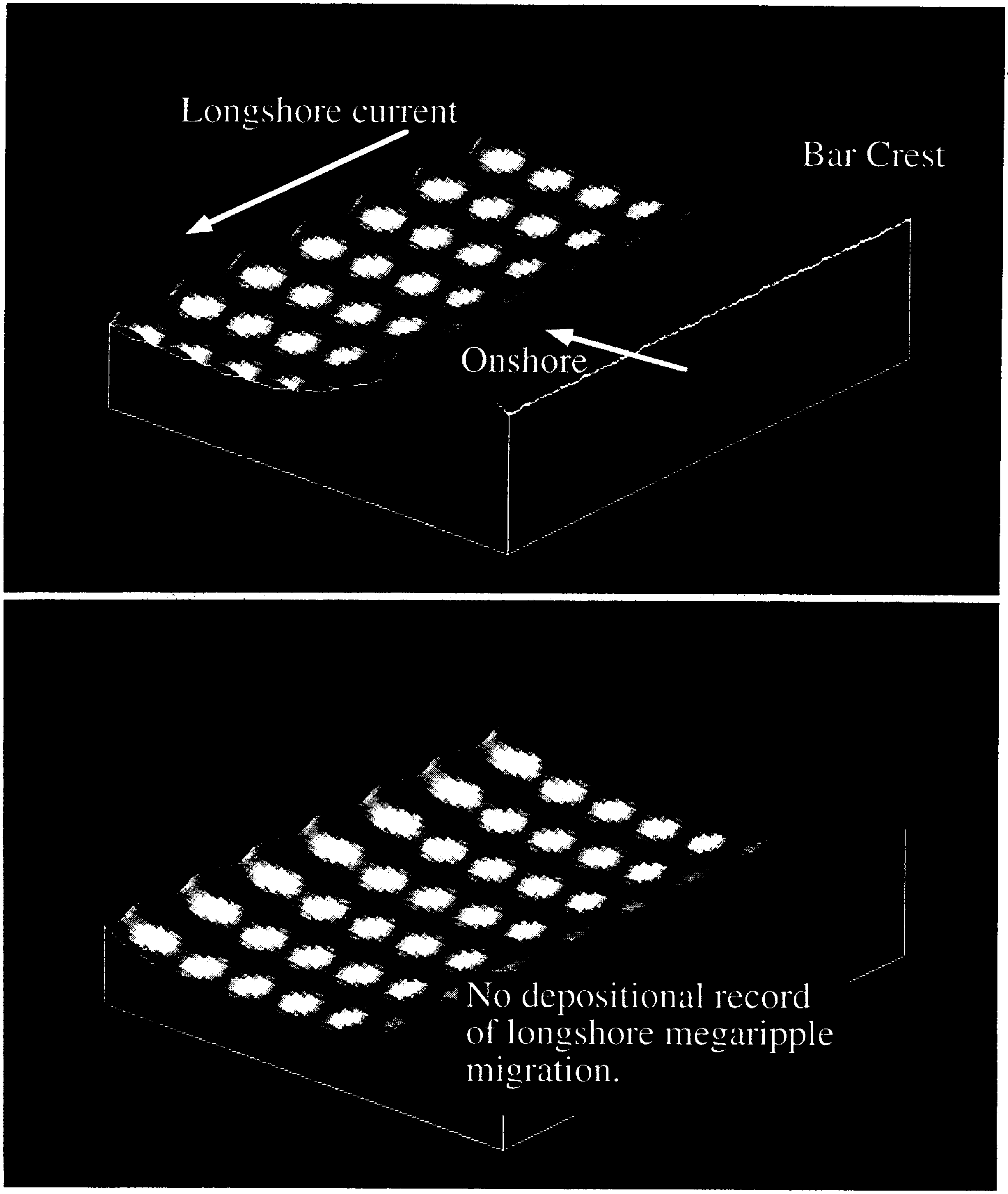

Figure 6. Alongshore migration of megaripples on the onshore side of the bar crest during offshore bar migration leaves essentially no sedimentary record of the processes effecting bar migration.

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References

Bailard, J. A. (1981). "An energetics total load sediment transport model for a plain sloping beach," *Journal of Geophysical Research* 86, 10,938-10,954.

Bowen, A. J. (1980). "Simple models of nearshore sedimentation; beach profiles and longshore bars". *The Coastline of Canada, Geological Survey of Canada Paper 80-10.* S. B. McCann, ed., 1-11.

Clifton, H. E., Hunter, R. E. and Phillips, R. L. (1971). "Depositional structures and processes in the non barred high energy nearshore," *Journal of Sedimentary Petrology* 41 (3), 651-670.

Gallagher, E. L. (1996). "Observations of seafloor evolution on a natural barred beach," *Ph.D dissertation,* University of California, San Diego, Scripps Institution of Oceanography, 63p.

Gallagher, E. L., Boyd, W., Elgar, S., Guza, R. T., and Woodward, B. (1996). "Performance of a sonar altimeter in the nearshore," *Marine Geology* 133, 241-248.

Greenwood, B. and Osborne, P. D. (1991). "Equilibrium slopes and cross-shore velocity asymmetries in a storm-dominated, barred nearshore system," *Marine Geology* 96, 211-235.

Hay, A. E. and Bowen, A. J. (1993). "Spatially correlated depth changes in the nearshore zone during autumn storms," *Journal of Geophysical Research* 98 (C7), 12,387-12,404.

Hunter, R. E., H. E. Clifton, and R. L. Phillips, (1979), "Depositional processes, sedimentary structures and predicted vertical sequences in barred nearshore systems," *Journal of Sedimentary Petrology*, 49, 711-726.

Riggs, S. R., Cleary, W. J., and Snyder, S. W. (1995). "Influence of inherited geologic framework on barrier island shoreface morphology and dynamics," *Marine Geology* 126, 213-234.

Rubin, D. M. (1987). "Cross-bedding, bedforms, and paleocurrents". *Concepts in Sedimentology and Paleontology,* 1, Society of Economic Paleontologists and Mineralogists, Tulsa, Oklahoma, 187 p.

Smith, J.B., Drake, T. G., Elgar, S. and Gallagher, E., (1995) "Do detailed hydrodynamic and sedimentologic data aid prediction of nearshore stratigraphy? Examples from the Duck94 Nearshore Field Experiment," *1995 Geological Society of America Annual Meeting Program*, 54.

Stauble, D. K. (1992). "Long-term profile and sediment morphodynamics: Field Research Facility case history". *U.S. Army Engineer Waterways Experiment Station Technical Report* CERC-92-7.