FIELD INVESTIGATION OF LONGSHORE TRANSPORT DISTRIBUTION

by

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ABSTRACT

Following a change in wave direction, the active contours in an idealized pocket beach respond by rotating such that they approach a perpendicular orientation relative to the incoming wave rays. Assuming that cross-shore sediment transport does not contribute to this contour rotation, and that the contours are in the early stages of this equilibration process, the amount of contour rotation can be interpreted as the cross-shore distribution of the longshore sediment transport.

As part of the Nearshore Sediment Transport Study, detailed nearshore profile measurements were conducted at Santa Barbara, California. Twenty-two of these profile lines were located on Leadbetter Beach, which is a quasi-pocket beach. To explore the concept described above, two of the nine intersurvey periods were selected due to their strong indications of wave direction change. Analysis of these data sets yielded two estimates of cross-shore distribution of longshore sediment transport which were compared with those presented by Komar, Fulford and Tsuchiya. Although these three distributions differ significantly, the effect of the tidal variations is to "smear" the differences in the inferred distributions as evident in the contour displacements. It was found that none of the relationships for longshore transport distribution predicted the amount of transport inferred in water depths greater than one meter. It is possible, especially for one of the intersurvey periods that the changes in contour locations were so extreme that substantial cross-shore sediment transport was induced and would be interpreted as longshore transport occurring in water depths greater than had actually occurred. The method introduced here should be useful in other field and laboratory programs to investigate the cross-shore distribution of longshore sediment transport.

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INTRODUCTION

Practically all coastal engineering projects require quantitative estimates of the longshore sediment transport at the project site. This information can be derived from a variety of sources including experience at nearby structures, channels which impound sediment and computations based on local wave characteristics. Generally, even if impoundment data are available, computations are employed, partly in the interest of developing confidence in the impoundment estimates, but also because of the uncertain quality of most impoundment documentation. For example, much of the initial nearshore accumulation at jetty structures can be the result of the onshore transport of a portion of the material which formerly resided in the ebb tidal shoal. In addition to the need for estimates of total longshore sediment transport, there are a number of project/problem types that require estimates of the distribution of longshore sediment transport across the surf zone. Examples include: design of the length and elevation of the weir section of a weir jetty system, design of the length of a groin or jetty, computation of the total longshore sediment transport in cases where a portion of the surf zone is paved by beach rock or particles too coarse to yield significant amounts of transport, etc.

The Nearshore Sediment Transport Study (NSTS) was sponsored by the National Sea Grant Office of the National Oceanic and Atmospheric Administration (NOAA); the objectives of this study included the enhancement of general knowledge and understanding of nearshore hydrodynamics and sediment transport processes with an emphasis on the improvement of the capability to compute longshore sediment transport for engineering purposes (Duane and Seymour, 1978). One component of the NSTS directed specifically at this latter objective was an eighteen month measurement program carried out at Santa Barbara, California. Through measurements of volume accumulations by the near-complete trap formed by the spit in the lee of the breakwater and portions of the updrift beaches, the net longshore transport could be documented with good accuracy. The wave characteristics were provided by two S_{xy} gages located in a water depth of approximately 7 m directly off Leadbetter Beach. The initial plan did not include an attempt to determine information relating to the cross-shore distribution of longshore sediment transport. However, as the data from a number of surveys accumulated, the "rotation" of the nearshore contours resulting from shifts in the dominant wave direction suggested that some of the available data sets were well-conditioned to address the problem of longshore sediment transport distribution.

REVIEW OF RELATED WORK

The difficulties of conducting field measurements of the cross-shore distribution of longshore sediment transport have prevented the determination of any well-accepted results. Methods attempted include bed load traps by Thornton (1973) and tracer studies. Thornton estimates the efficiency of the bed load traps to be between 40 and 100 percent. He also stated that the traps appeared to be more efficient under light wave conditions and tend to bury themselves under heavy wave conditions.

Thornton (1973), Komar (1977), and Tsuchiya (1982) have developed predictive equations for the cross-shore distribution of longshore sediment transport. Thornton utilized a Bagnold (1963) model and considerations of the role of the longshore current to develop a predictive relationship for $q_y(x)$, the distribution across the surf zone of the longshore sediment transport. Thornton's results expressed $q_y(x)$ as proportional to the product of the average energy dissipation per unit bed area and the longshore current. The proportionality factors were considered to be different inside and outside of the surf zone due to the different causes of energy dissipation. The field measurements conducted by Thornton included sediment transport as determined by the bed load traps and longshore currents based on surface float trajectories or current meters. The transport proportionality factor outside the surf zone exceeded that inside the surf zone by slightly more than an order of magnitude. There is substantial uncertainty regarding the efficiency of the bed load traps. Integrating Thornton's results across the surf zone results in a proportionality factor, K, for the total transport which is approximately two orders of magnitude less than the commonly accepted value of 0.77 (Das, 1972, Figure 6).

Komar combines the sediment transport concepts of Bagnold with longshore current distributions as developed by Longuet-Higgins (1970) and modified by Komar (1976). The resulting expression for $q_y(x)$ is proportional to the product of the bottom shear stress and the longshore velocity. Results are developed in which the bottom shear stress is based on the gradient of S_{xy} (the onshore flux of the longshore component of momentum) and this gradient augmented by the longshore current. Komar finds that the magnitude of $q_y(x)$ depends on the breaker height to depth proportionality factor, a mixing parameter which controls the form of the longshore current and the friction factor for the profile. The maximum of $q_y(x)$ is predicted to be at approximately $0.8\ x/x_b$, where x_b is the offshore breaking distance. Oue to the predicted abrupt discontinuity in bottom shear stress at the surf line, q_y is also discontinuous at this location. Additionally, Komar's distribution does not include any "swash" transport, i.e. landward of the mean water line. An example is presented in Figure 1.

Tsuchiya (1982) bases his predictive relationship on an equation which appears to be appropriate only for suspended sediment transport and which does not account for the correlation, over the vertical, of the suspended sediment distribution and the longshore current distribution. Tsuchiya combines the longshore current representation by Longuet-Higgins (1970) with earlier work conducted by Tsuchiya on sediment transport by currents. In the brief 1982 abstract, Tsuchiya does not present his method in detail; however, it appears that the basic form of the longshore sediment transport is approximately proportional to the product of the longshore current distribution and the depth. An example of Tsuchiya's results is presented in Figure 1, in which the continuity of sediment transport across the surf line and lack of swash transport are evident.

Fulford (1982) determined an empirical distribution of longshore sediment transport based on a wave basin study conducted by Savage

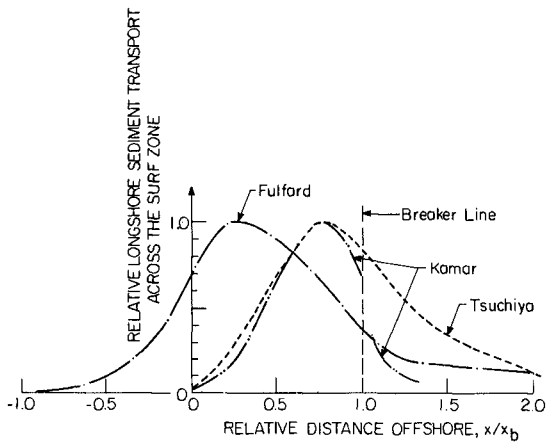


Figure 1. Illustration of Cross-Shore Distributions of Longshore Sediment Transport as Determined by Various Investigators.

(1959). In the tests utilized, Savage allowed the beach processes to equilibrate under the action of waves approaching at an angle. A long high impermeable groin was then introduced into the system. The analysis by Fulford was based on the two-dimensional equation of sand conservation

$$\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} - \frac{\partial h}{\partial t} = 0 \tag{1}$$

in which q_x and q_y represent the local sediment transport rates per unit width in the offshore and longshore directions, respectively and h represents the local water depth. To determine the distribution of $q_y(x)$, the above equation was integrated with respect to y

$$\int_0^y \frac{\partial q_x}{\partial x}\, dy + \int_0^y \frac{\partial q_y}{\partial y}\, dy = \int_0^y \frac{\partial h}{\partial t}\, dy \tag{2}$$

with the assumption that in the early stages of accumulation by the groin, the offshore sediment transport is zero, i.e. the first term is zero and the second term can be integrated directly to yield

$$q_y(x,y) - q_y(x,0) = \int_0^y \frac{\partial h}{\partial t}\, dy \qquad (3)$$

The second term is zero if the groin is impermeable. If the integration is carried out to a sufficient distance (y value), then the unaffected transport is determined. The distribution determined by Fulford is presented in Figure 1. Note that a considerable amount of transport is located in the "swash" zone and that the maximum of Fulford's distribution is considerably landward of those in the Komar and Tsuchiya distributions.

SITE CHARACTERISTICS

Santa Barbara is located on the Southern California coast, 150 km northwest of Los Angeles and 560 km southeast of San Francisco. The beaches lie on the Santa Barbara Channel which is separated from the Pacific Ocean by the Channel Islands. Because of the origin of the waves, the sheltering influence of the offshore islands, and the refraction of the waves (O'Brien, 1950), the wave pattern at Santa Barbara is nearly the same for most of the year, with the exception of infrequent waves from southeast storms.

During 1927-28 a detached rubble-mound breakwater with a concrete cap was constructed off Point Castillo to protect the Santa Barbara harbor. The breakwater was 1425 ft. in length roughly parallel to shore, with a 400 ft. arm directed towards shore. The resulting diffraction pattern in the lee of the breakwater caused the sand normally transported along the shore to be deposited in this area. Because of this undesirable effect, the breakwater arm was connected to shore in 1930 (Figure 2).

The now L-shaped breakwater was an effective trap of the longshore transport and the area west of the breakwater soon developed into a substantial beach (Leadbetter Beach) where the present experiment took place. Leadbetter Beach is therefore bordered on the east by the breakwater which, depending on beach contour planform, can act as an effective barrier to eastward sediment transport. The western end of Leadbetter Beach, approximately 1 km from the breakwater, is bordered by a high cliff, with many rocks at its base, extending oceanward to Santa Barbara Point. This western boundary essentially precludes any sediment transport out of Leadbetter Beach to the west. Wiegel (1964) has presented an excellent summary of the Santa Barbara breakwater construction history and resulting shoreline response.

After forming Leadbetter Beach, which represented a shoreline advancement of some 300 m, the sand moved along the breakwater and eventually began infilling the harbor area. By 1935 it was necessary to begin a program of periodic harbor dredging. From 1938 to 1953, maintenance dredging was done biennially, placing most of the dredged material on the beaches to the east, which had suffered substantial erosion after the breakwater construction. In 1954 it was decided to allow part of the continuously forming sand spit at the eastern end of

the breakwater to remain as protection to the harbor from southeast storms. A wooden structure has been constructed along the axis of the spit extending almost due north from a distance of about 20 meters to about 270 meters from the centerline of the breakwater. This spit area is believed to trap all the sand being transported alongshore at Santa Barbara and was used as the major site of NSTS Task 4-C (Dean, Berek, Gable and Seymour, 1982).

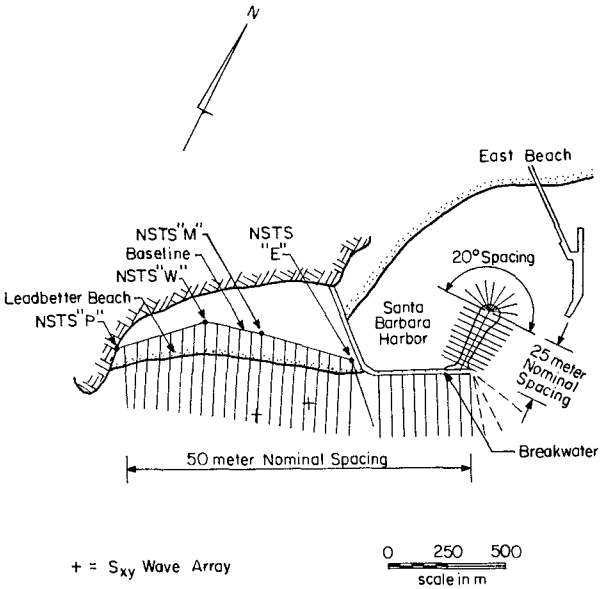


Fig. 2. Study Site, Survey Lines, and Location of the Two S_{xy} Wave Arrays

SURVEY PROCEDURES

Ten surveys were conducted at Santa Barbara from October 1979 to February 1981 (see Table I). Conventional land surveying techniques, overlapped by bathymetric surveys were utilized. Survey lines were run on the spit, on the seaward side of the breakwater and along Leadbetter Beach. A total of 22 lines were surveyed on Leadbetter Beach, two originating from the same point near the "elbow" of the breakwater, the others being at 50 m intervals along the beach, see Figure 2 for a survey plan and location of the S_{xy} gages.

The bathymetric survey was accomplished by a recording fathometer from a boat precisely located by a Cubic Autotape system. To eliminate the effects of waves, each line was surveyed three times and the depth and distance determined by averaging the values obtained over a five meter interval in the offshore direction.

Table I. Survey Oates

Survey Number	Survey Oates
1	10/18/79 to 10/22/79
2	11/30/79 to 12/04/79
3	01/20/80 to 01/25/80
4	02/25/80 to 03/01/80
5	04/10/80 to 04/13/80
6	06/03/80 to 06/09/80
7	08/25/80 to 08/28/80
8	10/22/80 to 10/25/80
9	12/16/80 to 12/20/80
10	02/26/81 to 02/28/81

Tide elevations in Santa 8arbara Harbor were documented during the bathymetric surveys to correct the fathometer data to Mean Sea Level. In addition, the surveys were checked at distances far offshore at water depths presumed sufficiently great to be outside the region of sediment transport. Fathometer calibrations were made frequently during bathymetric surveys.

In addition to the sediment data, wave information was obtained by an S_{xy} array consisting of four bottom-mounted pressure sensors as described by Seymour and Higgins (1978). In general, wave data were recorded at six-hour intervals.

8each profiling was performed during low tide periods, whereas the boat surveys took place during high tides to attempt to maximize overlap distance as much as possible. The profiles were taken with rod and level at five meter intervals, or pronounced changes in beach slope. In general, the overlap was satisfactory. The survey line locations are shown in Figure 2. A more complete description of site characteristics and survey procedures is provided by Oean, 8erek, Gable and Seymour (1982)

ANALYSIS METHOOS

Interpretation of Idealized Pocket Beach Response

The estimation of the longshore sediment transport distribution across the surf zone is based on the idealized response characteristics of a pocket beach to a change in wave direction. If no sediment flux into or out of a pocket beach can occur, and if a change in wave direction occurs, the pocket beach will respond such

that the contours will approach an orientation which is approximately perpendicular to the incident wave direction. Other contour modifications can occur due to a change in wave height and/or period. For example, it is well-known that an increase or decrease in wave steepness without a change in wave direction can cause the profile to flatten or steepen, respectively. Figure 3 summarizes the assumptions utilized in this study: that the even and odd portions of the contour displacements are due to cross-shore and alongshore sediment transport, respectively.

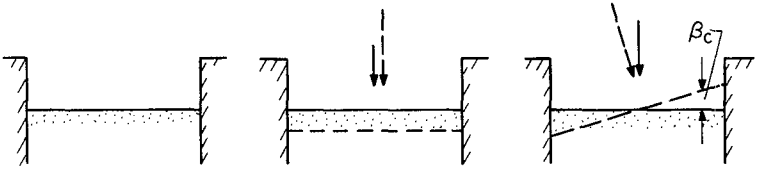


Figure 3. Representative Contour Displacement Signatures for an Idealized Pocket Beach Due to Cross-Shore (Sketch b) and Longshore (Sketch c) Sediment Transport.

The interpretation of the odd component of the beach contour displacements is as follows. Consider the contour changes shown in Figures 3b) and c) and the two dimensional equation of continuity.

$$\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} - \frac{\partial h}{\partial t} = 0 \tag{4}$$

If the depth change effect is separated into an even component $(\frac{\partial h}{\partial t})_e$ due to the cross-shore sediment transport and an odd component $(\frac{\partial h}{\partial t})_o$ due to alongshore sediment transport, then by assumption

$$\frac{\partial q_x}{\partial x} = (\frac{\partial h}{\partial t})_e \tag{5}$$

$$\frac{\partial q_y}{\partial y} = (\frac{\partial h}{\partial t})_o \tag{6}$$

It is the odd component which will be of primary concern here. Since contour displacements, rather than depth changes are required, the transformation is introduced relating the time rate of change in depth to the time rate of displacement of a particular contour h_c, i.e.

$$\left(\frac{\partial h}{\partial t}\right)_o = \frac{\partial h_c}{\partial x}\left(\frac{\partial x_c}{\partial t}\right)_o = \frac{\partial q_y}{\partial y} \tag{7}$$

and where $\left(\frac{\partial h_c}{\partial x}\right)$ is the slope, m_c, of the beach profile at the contour of interest. Integrating from an arbitrary location y to the end of the beach compartment, $y = \ell$, where the transport, q_y is zero,

$$q_y(h_c,y) = - m_c \int_y^{\ell} \left(\frac{\partial x_c}{\partial t}\right)_o dy \tag{8}$$

which relates the longshore transport along a particular contour, h_c, to the integral of the time rate of displacement of that contour. If the location y is taken as the centerline of the pocket beach and if the contour change is approximately linear as shown in Figure 3c, with slope, β_c, then the magnitude of the longshore sediment transport rate is

$$|q_y(h_c,y)| \propto m_c \tan\beta_c \tag{9}$$

Without discussing in detail the time response of a particular contour to a change in wave direction, it is relevant to note that the initial effects are manifested at the ends of the compartment and that an odd contour change that is linear is indicative of an adjustment that has nearly achieved equilibruim under the changed wave direction. The ideal data set for establishing the transport distribution is one in which all of the contours have rotated sufficiently to allow volumes transported to be measured accurately, but a sufficiently small transport such that offshore transport has not been induced nor has equilibrium been achieved. In the general case, it would be necessary to employ Eq. (8) rather than Eq. (9).

There are three main limitations to the method described for determining the distribution of longshore sediment transport from contour rotations in pocket beaches. The first and most obvious limitation is that the pocket beach should be "sand tight" such that any alongshore transport along a contour will be manifested by a rotation of that contour rather than by being transported out of the system. The second limitation is that the method assumes that sand transported along a contour will remain on that contour. It is clear that as a result of steepening or flattening of a profile, offshore and onshore sediment transport will occur, respectively. The final limitation relates to the duration between intersurvey periods relative to the time required for the system to achieve equilibrium under the altered wave conditions. Given sufficient time, all active contours would "rotate" into the incoming wave direction and therefore it would be impossible to determine any information relating to the cross-shore distribution of longshore sediment transport. Thus the response should be documented in the early stages of the equilibration process.

Determination of Odd and Even Contour Displacement Components

For each survey, the locations of various depth contours were determined from the data by interpolation. The computer program which determined these locations also established the changes in the contour positions between consecutive surveys. These contour displacement data were then smoothed and the number of lines along Leadbetter Beach reduced to ten, resulting in a spacing of one hundred meters between lines. This smoothing was accomplished by a simple moving average filter:

$$X_1 = x_1 \tag{10}$$

$$X_i = 0.25\, x_{2i-2} + 0.50\, x_{2i-1} + 0.25\, x_{2i} \; ; \; i = 2, 10$$

where: X_i = smoothed displacements
x_i = measured displacements

To separate the contour displacements into even and odd components, the following formulas were used:

$$(f_{odd})_i = \frac{X_i - X_{(N-i)}}{2} \tag{11}$$

$$(f_{even})_i = \frac{X_i + X_{(N-i)}}{2} \tag{12}$$

where: N = total number of points (i.e., 10)

The odd parts of the contour displacements are, by definition, antisymmetric about an axis through the center of the beach planform. This axis is therefore a pivot point about which contour rotations are measured.

Wave Analysis

Wave information was obtained throughout the period of study from an S_{xy} array consisting of four bottom mounted pressure sensors, as described by Seymour and Higgins (1978). Wave recordings were normally available every six hours and spectral information summarizing the wave characteristics of each recording period was provided by R. J. Seymour and D. Castel of the Scripps Institute of Oceanography.

For longshore transport calculations the wave quantities of particular importance are the root mean square breaking wave height, H_b, and the breaker angle, α_b. A value of P_{ls}, the longshore component of wave energy flux, was calculated as

$$P_{ls} = C_1 (H_b)^{5/2} \sin 2\alpha_b$$

where C_1 is a proportionality factor and H_b and α_b were obtained by refraction and shoaling computations which transformed the data from the gage location to the breaker line.

Prediction of Average Longshore Transport Along a Particular Contour Including the Effect of Tidal Variations

Consider the application of a particular predictive distribution for longshore sediment transport, $q_y'(x)$. In this relationship, the origin of x is at the mean water line and the application must account for the effect of the varying tide, $\eta_T(t)$. In the approach utilized herein, the distribution with distance $q_y'(x)$ was first transformed to a distribution with depth, $q_y''(h)$, by the relationship

$$q_y''(h) = \frac{1}{m_c} q_y'(x) \tag{13}$$

in which the beach slope, m_c, was determined from the representative beach profile presented in Figure 4.

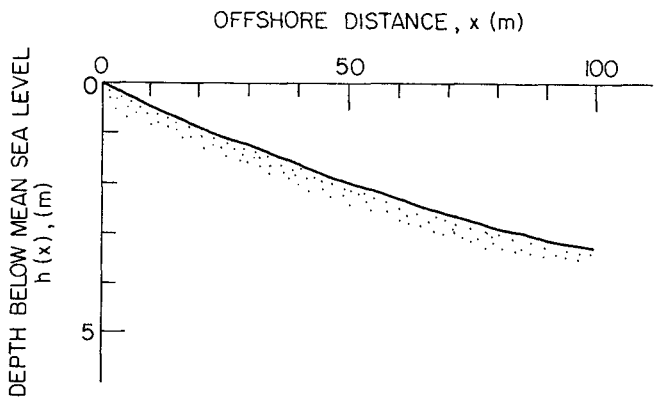


Figure 4. Representative Beach Profile.

The longshore sediment transport along a particular depth contour (h_c) then becomes

$$q_y(h_c,t) = P_{ls}(t)\, q_y''(h + \eta_T(t)) \tag{14}$$

where the distribution $q_y''(h)$ is normalized to unit area and is scaled at each time in accordance with the breaking depth $h_b(t)$ associated

with each $P_{ss}(t)$. This procedure is illustrated schematically in Figure 5. The values of $q_y(h_c,t)$ were calculated for the time-varying tide and wave characteristics at time increments of one hour. The average computed longshore transport values for each contour were determined by integrating Eq. (3) over the time interval of the intersurvey period. These computations were carried out for the distributions of Komar, Fulford and Tsuchiya as presented in Figure 1.

RESULTS

Two intersurvey periods showing significant planform rotations have been analyzed: June-August, 1980 and October-December, 1980. The character of the net beach response to the wave environment was fundamentally different in the two cases; this difference will be discussed briefly. Considering the schematic diagram of Leadbetter Beach in Figure 6, the beach contours during the June-August period rotated counterclockwise (Figure 6a), and during the October-December period the rotation was clockwise (Figure 6b). Because the breakwater does not extend sufficiently far seaward to prevent all the longshore transport, the system is "leaky" when the contours rotate clockwise. When the contours rotate counterclockwise the system is "sediment tight" or "not leaky".

Following the procedure described earlier for the determination of the odd components of the contour displacements, the survey data were analyzed and the results are presented in Figures 7a) and 7b). The odd components are of course antisymetric about the center-line of the beach compartment. Based on these figures, values for the slopes of the contour displacements, β_c, defined in Figure 1c were determined. The resulting transport is proportional to the product of tan β_c and the local beach slope, m_c,

$$q_y \propto m_c \tan \beta_c$$

It is of interest to note that for the October to December intersurvey period, the value of β_c decreases monotonically from the mean sea level contour to the deeper contours. The value of β_c for the June to August period changed in a more complex manner; first increasing slightly from the mean sea level contour to the 1.0 meter contour, followed by a decrease. This pattern leads to a very different expected profile for $q_y(x)/q_y(0)$ for the two intersurvey periods, as shown in Figure 8. The June-August period distribution shows the transport distributed over a much wider range of depths, with transport being greater than $q_y(0)$ to the 1.0 meter contour.

These two measured distributions have been compared with three predicted distributions, which are also shown in Figure 8, and are due to Komar (1977), Fulford (1982), and Tsuchiya (1982).

During the June to August intersurvey period and for depths greater than 0.5 m, all of the predicted transport distributions are less than that inferred from the measured contour displacements. Recalling the earlier discussion of the effect of large contour

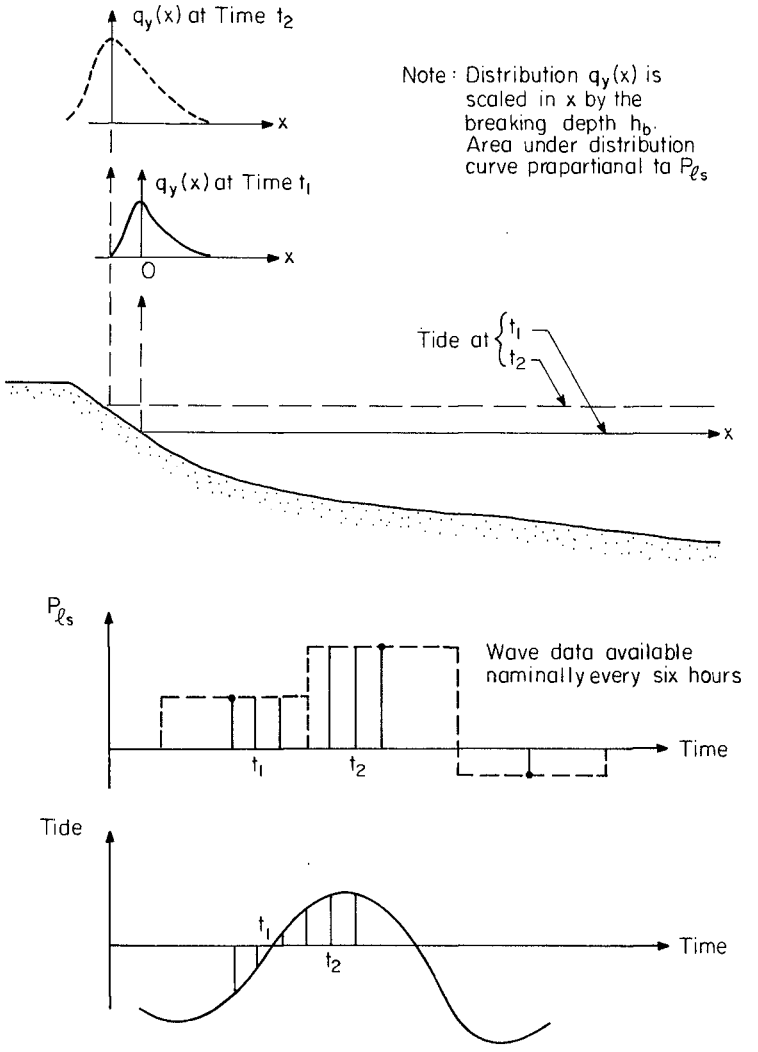


Figure 5. Illustration of Procedure for Predicting Longshore Transport Distribution for Varying Wave Conditions and Fluctuating Tides.

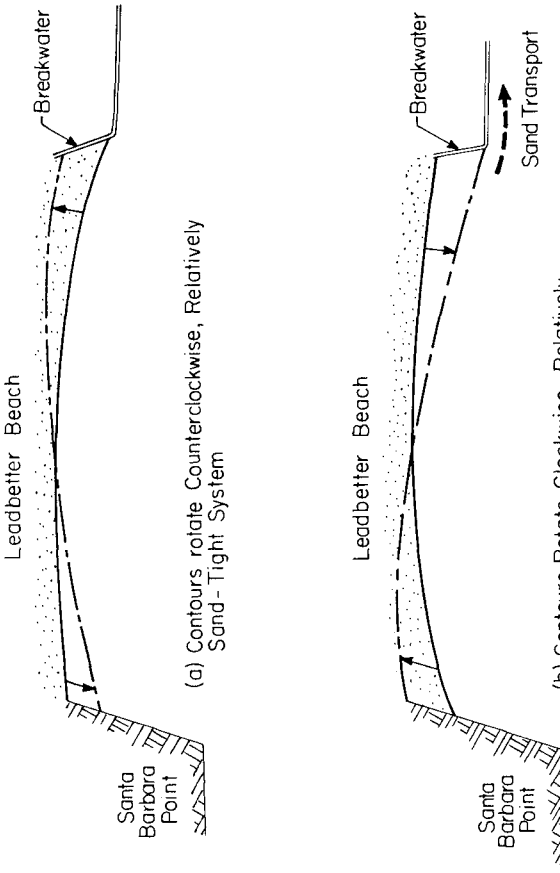


Figure 6. Illustration of Different Sand Retention Characteristics for Clockwise and Counterclockwise Rotation of Beach Contours

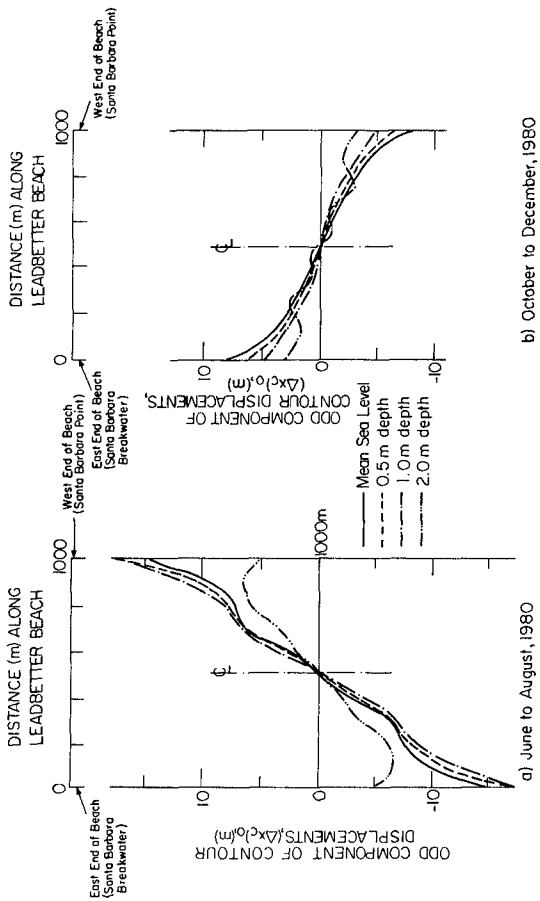
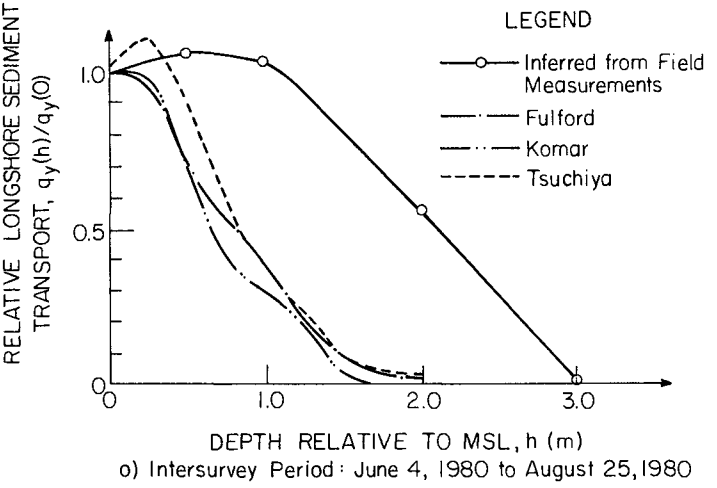
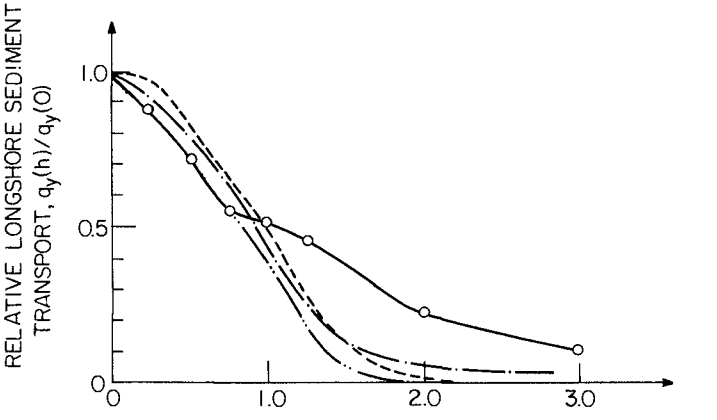


Figure 7. Odd Components of Contour Displacements for Two Different Intersurvey Periods



a) Intersurvey Period: June 4, 1980 to August 25, 1980



b) Intersurvey Period: October 23, 1980 to December 17, 1980

Figure 8. Comparison of Predicted Relative Longshore Sediment Transport Distributions with the Distributions Inferred from Field Measurements

displacements on the inferred distribution and referring to Figure 7a and Figure 4, it appears likely that the contour displacements of approximately 17 m at the ends of the pocket beach compartment may have caused cross-shore transport. As noted, under the assumptions employed herein, the deposition resulting from cross-shore sediment transport would be interpreted as longshore sediment transport in greater water depths than had actually occurred. Moreover, the triangular distributions of the contour displacements for this intersurvey period (Figure 7a) suggest that an equilibrium planform had been achieved, at least for depths of 1 m and shallower. Although the contour displacements were in a direction such that the compartment should be sand tight, the violations of the assumptions as noted above would appear to invalidate the results of this particular intersurvey period as a basis for evaluating the cross-shore distribution of the longshore sediment transport.

The contour displacements associated with the October to December intersurvey period are clockwise and thus the pocket beach would tend to be "leaky". However, examination of these displacements in Figure 7b indicates that the other two requirements are satisfied much better than for the earlier intersurvey period: (1) the contour displacements are much smaller, and (2) the form of the displacements suggests that the equilibration process may be in the early to intermediate stages. The comparison of the distribution inferred from measurements and those based on the predictions is presented for this intersurvey period in Figure 8b. In water depths less than approximately one meter, there is good general agreement, with the Komar distribution providing the best fit. In greater depths all predicted transport values are less than the measured with Fulford results being in slightly better agreement than the other two. It appears that in water depths greater than one meter, there may be some effect of cross-shore transport induced by the contour displacements.

SUMMARY AND CONCLUSIONS

Summary

Following a change in wave direction, the active contours in an idealized pocket beach will respond by rotating such that they approach a perpendicular orientation relative to the incoming wave rays. A method has been presented for interpreting the rotation of various contours to determine the cross-shore distribution of the longshore sediment transport. The requirements for the method to be applicable are: 1) the longshore and cross-shore transport gradients result in odd and even changes in the position of a contour, respectively, (2) the pocket beach compartment should be sand tight, (3) the contour displacements should be sufficiently small that only minimal cross-shore transport is induced as a result of the perturbation of the equilibrium beach profile, and (4) the contour displacements should be documented while the equilibration process is in its initial stages.

The method has been evaluated by analyzing the NSTS Leadbetter Beach profile data from two intersurvey periods. These results are

compared with predictions based on three proposed longshore transport distributions.

Conclusions

1. The two intersurvey periods analyzed herein were for June to August, 1980 and October to Oecember, 1980. Neither of these two data sets satisfy entirely the requirements identified for determining the longshore sediment transport distribution from contour displacements. For the first period, the contour rotation was counterclockwise such that the compartment would be sand tight; however, the amount of change and duration of transport prior to documentation appear to result in an indication of excessive transport in water depths greater than one meter. For the second period, the clockwise rotation of the contours tends to result in a somewhat "leaky" system. However the character of the contour displacement indicates that little cross-shore transport was induced and that the equilibration process was in the early stages. Thus, greater confidence is assigned to the second intersurvey period.

2. Although the forms of the three trial distributions differ substantially, the effect of "tidal smearing" is to reduce these differences as manifested in predicted contour displacements and inferred distributions.

3. Although the three distributions (after tidal smearing) are not markedly different, for the second intersurvey period, which is considered to satisfy more completely the requirements of the method, the distribution of Komar provides the best agreement in depths less than one meter and that of Fulford agrees best in water depths greater than one and one-half meters.

4. To better evaluate candidate distributions, it would be desirable to apply the procedure in locations where no tide is present, such as the Great Lakes if a beach segment with proper planform controls could be identified. If applied in areas with tides, the tide range should be small compared to the representative breaking wave height.

5. It is hoped that the method will be useful in further determinations of the cross-shore distribution of longshore sediment transport, both in laboratory and field studies.

ACKNOWLEDGEMENTS

The financial support provided by the Sea Grant Program to this component of the Nearshore Sediment Transport Program is greatly appreciated. The encouragement and guidance of Dr. David Duane as Technical Monitor of that program was especially valuable as was that of Or. R. J. Seymour as Program Manager. The dedicated and professional efforts of Mr. C. G. Gable of Scripps Institute of Oceanography and personnel of Ocean Surveys, Inc. in the field surveys contributed significantly to the quality of the field data. Finally, the University of California at Santa Barbara was very helpful by

providing vessels and highly competent personnel to assist in the field efforts.

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