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A Beach Profile Model for a Barred Coast—Case Study from Sand Key, West-Central Florida

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ABSTRACT

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A three-segment beach profile model which is capable of reproducing the commonly observed bar and trough features was developed and calibrated with 122 measured profiles from Sand Key, Florida. The bar and trough features are important parts of a nearshore equilibrium system due to their dynamic response to both short-term and long-term changes of wave-conditions. The beach profile is divided into three independent segments: inner surf zone, landward slope of breakpoint-bar, and nearshore zone (seaward from the bar top). The commonly used $h = A_1x^{2/3}$ form describes the inner surf zone well. The landward side of the bar is described by a plane slope. The nearshore portion of the beach profile is describe by another power function in the form of $h = A_2(x - x_2)^{m2}$. The parameter, x_2, which is related to the distance from the shoreline to the bar top, is introduced to link the inner surf and nearshore portions. The scale parameters A_1 and A_2 are related to sediment grain size and its distribution. The present model requires the input of two elements of morphological information for subdividing the profile into the three segments. They are the distances from the shoreline to the trough bottom (x_{tr}) and the bar top (x_{bt}). A set of empirical formulas was developed for the barred coasts along the west-central Florida. The empirical parameters obtained from the Florida Gulf coast are rather different from those obtained from the Pacific coast in southern California, indicating a significant regional geological and oceanographic control.

ADDITIONAL INDEX WORDS: *Barred beach profile, beach profile modeling, cross-shore sediment transport, equilibrium beach profile, west Florida coast.*

INTRODUCTION

Numerical description of beach profile is essential in quantifying nearshore processes and coastal development. The concept of equilibrium beach profile (*e.g.*, SCHWARTZ, 1982; DEAN, 1983; LARSON, 1991) has been used as a guidance for quantitative beach profile description. Generally, the equilibrium concept infers that a beach of specific sediment grain size responds to wave forcing by adjusting to a constant equilibrium shape attributable to a given type of incident wave. Two equilibrium mechanisms have been suggested: 1) the beach profile adjusts so that the average wave-energy dissipation rate per unit water volume is uniform (DEAN, 1977), and 2) a local balance in the transport energetics, which results in an equilibrium slope, is reached (INMAN and BAGNOLD, 1963; BAILARD, 1981; BAILARD and INMAN, 1981).

Numerous studies, mainly from statistical approaches, have been conducted to quantitatively describe beach profiles. A commonly used method is profile averaging and least-squares curve fitting (*e.g.*, BRUUN, 1954; DEAN, 1977; BODGE, 1992; INMAN *et al.*, 1993). The mechanisms described above were generally used as guidelines and to explain the curve-fitting results. One of the most frequently used beach profile models which was originally proposed by BRUUN (1954) and further developed by DEAN (1977) is

$$h = Ax^m \tag{1}$$

where h is the still-water depth, x is the horizontal distance from shoreline, A is a dimensional scale parameter determined mainly by sediment grain size, and the empirical shape coefficient, m, was found to be equal to ⅔. Numerous modifications of Equation 1 were proposed in more recent studies (*e.g.*, LARSON, 1988; LARSON and KRAUS, 1989; DEAN, 1991; LARSON, 1991; WORK and DEAN, 1991; MOUTZOURIS, 1991), mainly to improve the prediction of the profile in the vicinity of the shoreline and to include the influence of varying sediment grain size across the profile.

Utilizing the same data (504 beach profiles) as in DEAN's (1977) analysis, BODGE (1992) proposed an exponential function

$$h = B(1 - \exp(-kx)) \tag{2}$$

where B and k are dimensional empirical constants. BODGE (1992) concluded that the majority of the beach profiles (60% to 71%) were better fit by the exponential function (Eq. 2) relative to the power function (Eq. 1) of BRUUN (1954) and DEAN (1977). A better fit of the exponential function was also found by KOMAR and MCDOUGAL (1994) using a beach profile

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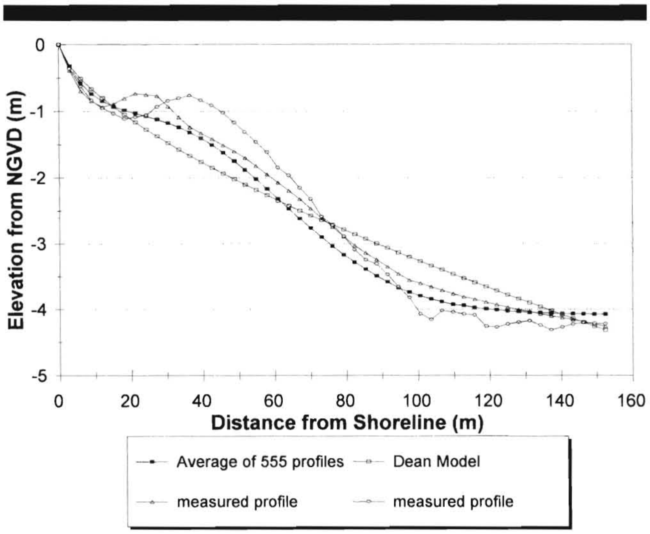

Figure 1. A comparison of the average and measured profiles. Two examples from the 555 measured profiles are included. The bar and trough features are significantly reduced on the average profile which is reproduced well by DEAN (1977) model.

from the Nile Delta. The relationship between the dimensional B and k, which were determined statistically in BODGE's (1992) study, and hydrodynamic and morphodynamic conditions is not clear. Since B is the maximum depth for the exponential prediction, it is reasonable to believe that, for practical purpose, B should be equal to or larger than the closure depth. The B values obtained by BODGE (1992) for 4 of the 10 profile groups are less than 3.7 m. An extremely low and unreasonable value of 2.62 m was suggested for the groups from Folly Beach, South Carolina to Tybee Island, Georgia. Further studies on the relationship between closure depth and the parameter B are needed for the application of the exponential function. Parameter k determines the curvature of the profile.

Both the exponential (Eq. 2) and power (Eq. 1) functions are monotonic, *i.e.*, the water depth increases and the beach slope decreases monotonically seaward. The monotonic models neglect the commonly observed nearshore bar and trough features. The dynamic bar and trough were usually reduced significantly during the profile averaging (Figure 1). It has been demonstrated by many studies that the power function of BRUUN (1954) and DEAN (1977) is capable of reproducing the general shape of average nearshore profiles reasonably well (*e.g.*, BRUUN, 1954; DEAN, 1987; 1991; HANSON and KRAUS, 1989; BODGE, 1992).

INMAN *et al.* (1993), realizing that the forcing mechanism landward and seaward of the breakpoint-bar can be significantly different, divided the beach profile into two independent portions separated by the bar. The two portions were termed (INMAN and DOLAN, 1989) as bar-berm, landward of the breakpoint-bar, and shorerise, seaward of the breakpoint-bar (here called nearshore). Two power functions similar to Equation 1 were used independently to reconstruct the two segments. It was demonstrated (INMAN *et al.*, 1993) that the barred profiles were reproduced better, especially in the vicinity of the bar and the offshore portion, than the one-segment model of BRUUN (1954) and DEAN (1977) using the two-segment model (Figure 2). The two segments in the model of INMAN *et al.* (1993) are connected at the breakpoint bar. The slope change at the connection creates a "bar-like" feature (Figure 2). The landward slope of the bar and the local seaward decrease of water depth were ignored.

The empirical eigenfunction analysis (EOF) is another commonly used method to statistically describe beach profile and its changes (*e.g.*, WINANT *et al.*, 1875; UDA and HASHIMOTO, 1982; AUBREY and ROSS, 1985; PRUSZAK, 1993; HSU *et al.*, 1994). The EOF method provides a statistical tool to describe temporal and spatial beach-profile changes. The statistical results were often explained applying the existing knowledge on regional sediment transport (*e.g.*, WINANT *et al.*, 1975; AUBREY and ROSS, 1985). The general shape of a number of beach profiles, often referred to as "mean beach function" (WINANT *et al.*, 1975), can be described by the eigenfunction with the largest eigenvalue (the first eigenfunction). The "mean beach function" was often eliminated from further EOF analysis in order to emphasize the beach-profile changes. The capability of the EOF method to predict the beach profile is uncertain due to the lack of knowledge on the exact form of the first eigenfunction and its relationship with transport physics.

A nearshore bar exists along many coasts and is one of the most commonly observed nearshore features. It has been demonstrated by numerous investigations that the movement of the nearshore bar corresponds to changes of wave conditions, *e.g.*, the well known winter and summer beach cycles in California (*e.g.*, SHEPARD, 1950a; 1950b; INMAN and RUSNAK, 1956; NORDSTROM and INMAN, 1975; WINANT *et al.*, 1975; AUBREY and ROSS, 1985), bar migration induced by short-term weather change (*e.g.*, DAVIS and FOX, 1972; FOX and DAVIS, 1976) and storm waves (*e.g.*, HOWD and BIRKEMEIER, 1987; LARSON and KRAUS, 1994; DAVIS and WANG, 1997). Bar-migration rates up to 18 m/day were measured by LARSON and KRAUS (1994) at DUCK, North Carolina during storm conditions. In the recent SUPERTANK laboratory experiment (KRAUS and SMITH, 1994), a nearshore bar was developed on a beach profile which was originally configured with the form of Equation 1 (*e.g.*, Test ST_10A, KRAUS and SMITH, 1994). The bar development was used to quantify the unbalanced cross-shore sediment transport in the SUPERTANK study. All the above facts indicate that bar and trough are important elements of the nearshore equilibrium system, they respond to long-term and short-term, as well as normal and event hydrodynamic changes.

In the present study, a modified INMAN *et al.* (1993) approach was used to divide a beach profile into segments. One hundred and twenty-two profiles with prominent bar and trough features were selected from 555 profiles surveyed at 71 locations along Sand Key beaches. The included profiles were measured before or at least 2 to 3 years after the beach nourishment. It is believed that 2 to 3 years is long enough for the nourished beach to reach dynamic equilibrium. Roughly equal amounts of summer and winter profiles were

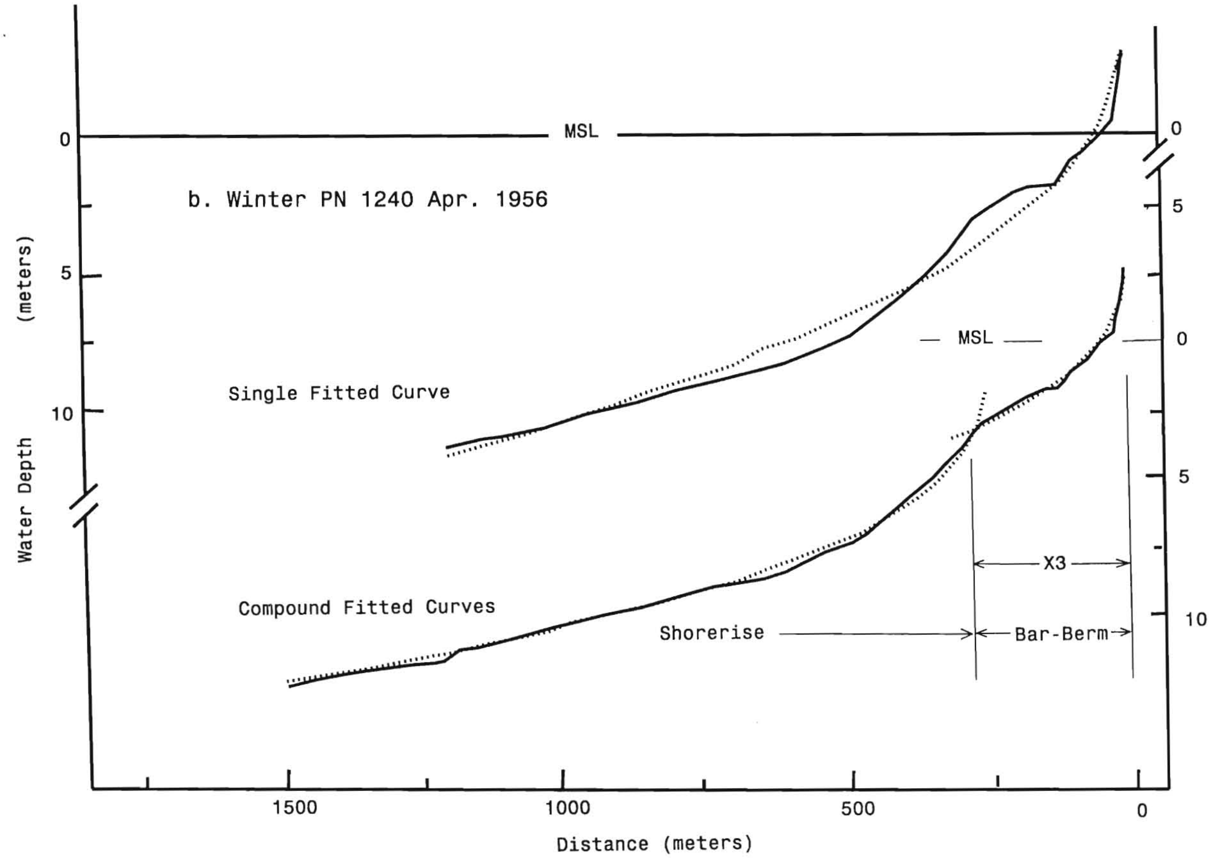

Figure 2. Comparison of the two-segment model of INMAN *et al.* (1993) with the one segment monotonic model. The measured profile (solid line) was reproduced (dotted line) better by two-curve model (from INMAN *et al.*, 1993), especially in the bar/trough and offshore areas.

selected to include any possible seasonal influences. These 122 profiles were used to verify and calibrate the proposed beach profile model. Comparisons with the commonly used DEAN (1977) model and the studies from southern California coast are also discussed.

MODEL DEVELOPMENT

It has been demonstrated by numerous studies that the power function of BRUUN (1954) and DEAN (1977) describes the general trend of beach profile shape, *i.e.*, the seaward increase of water depth. The influence of sediment grain size is reflected reasonably well by the parameter A. The derivation of DEAN (1977) demonstrating that Equation 1 is consistent with a uniform rate of energy dissipation in the surf zone shows that the power function reflects the transport processes to a certain extent. It is, therefore, reasonable to assume that, although Equation 1 does not describe the exact force balance between fluid and sediment, it does incorporate a key feature of the governing transport mechanism. The existence of the bar/trough features indicates that the uniform energy dissipation may not be continuos throughout the whole barred profile. Seaward of the breakpoint bar, the wave energy may be dissipating in a uniform pattern I, and as the wave enters the inner surf zone, the wave energy may be dissipating in a uniform pattern II. These two energy dissipation patterns are connected by the wave reformation in the trough. Therefore, the barred profile may be described by a series of Ax^m forms, as in the approach of INMAN *et al.* (1993).

A third segment describing the landward slope of the bar was added in between the barberm and shorerise (here called nearshore) portions of INMAN *et al.* (1993). The three segments (Figure 4) used in the current study are: 1) nearshore zone, from top of the bar to the closure depth, dominated by wave shoaling and breaking on the bar top; 2) landward side of the bar, characterized by a landward dip and a landward increasing depth; the dominant hydrodynamic process is rapid energy dissipation at the bar top due to wave breaking and reformation caused by increasing water depth; and 3) inner surf zone, from the bottom of the trough to the shoreline, dominated by secondary wave shoaling and breaking. The three segments are calculated independently. The power function in the form of Equation 1 is used to describe the nearshore and inner surf zones. The landward side of the bar, which connects the inner surf and the nearshore portions, is generally narrow and represented here by a plane slope. The three segments are expressed as

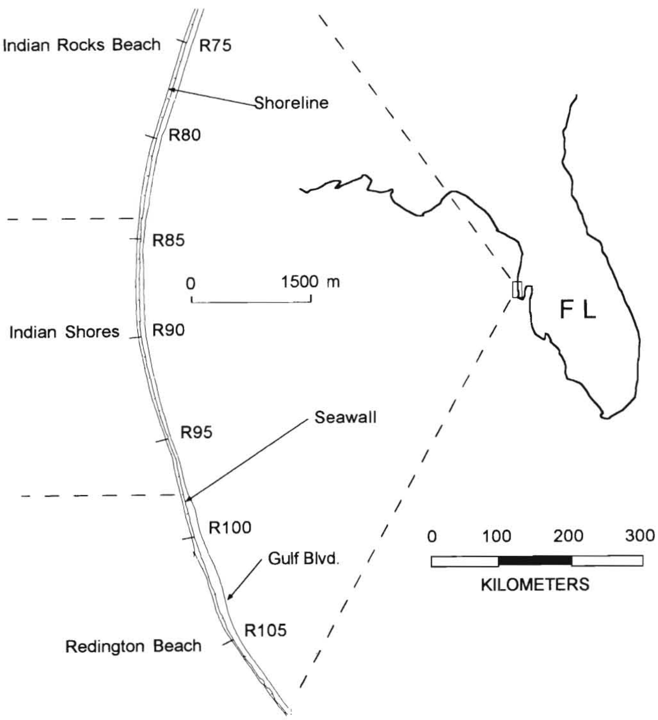

Figure 3. The study area on the Florida Gulf coast, profiles R70 to R84 are located on Indian Rocks Beach, R85 to R98 on Indian Shores, and R99 to R109 on Redington Beach.

inner surf zone:

$$h(x) = A_1 x^{m_1} \qquad \text{for} \quad 0 < x \le x_{tr} \qquad (3)$$

landward bar-slope:

$$h(x) = h_{tr} + \frac{h_{bt} - h_{tr}}{x_{bt} - x_{tr}}(x - x_{tr}) \quad \text{for} \quad x_{tr} < x < x_{bt} \qquad (4)$$

nearshore zone:

$$h(x) = A_2 (x - x_2)^{m_2} \qquad \text{for} \quad x_{bt} \le x < x_{cd} \qquad (5)$$

where A_1 and A_2 are dimensional scale parameters for inner surf and nearshore zones, respectively, m_1 and m_2 are empirical shape parameters controlling the beach slopes, h_{tr} and x_{tr} are water depth at trough bottom and its distance to the shoreline, x_2 is the intercept of the nearshore portion with 0 water level, h_{bt} and x_{bt} are water depth at bar top and its distance to the shoreline, x_{cd} is the distance from shoreline to the seaward limit of the profile, *e.g.*, closure depth.

The above model (Eqs. 3 to 5) requires the input of three basic parameters describing the general characteristics of bar/trough morphology plus sediment grain size. The distance from shoreline to trough bottom (x_{tr}) is needed to separate the inner surf zone from the landward side of the nearshore bar. The distance from bar top to shoreline (x_{bt}) is needed to separate the nearshore portion from the landward side of the bar. Sediment grain size and its distribution is helpful in determining the scale parameters (DEAN, 1987).

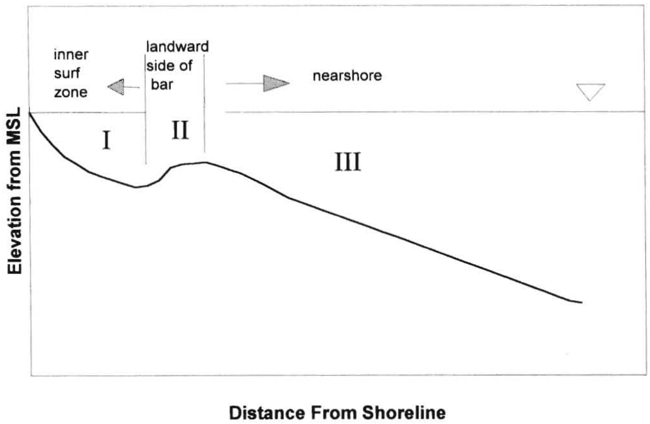

Figure 4. The three segments used to describe a beach profile.

The parameter, m_1 (Eq. 3), describing the shape of the profile in the inner surf zone was determined to be ⅔ here based on DEAN's (1977) analysis. Examples of predicted (best-fit) and measured profiles are presented in Figure 5. The present model is capable of reproducing pre- and post-nourishment (Figures 5I and 5II) as well as winter and summer (Figure 5III) beach profiles. The agreement between measured and predicted profiles is satisfactory as indicated by the close-to-unit ratio of measured (h_{mea}) and predicted depth (h_{pre}). Remarkable improvement over the monotonic models is achieved for the modeling of measured profiles, especially in the vicinity of the bar/trough (Figure 6) and offshore region.

CASE STUDY FROM SAND KEY BEACHES, FLORIDA

The three-segment model proposed in the present study was applied to the 122 beach profiles having prominent bar and trough features from the Sand Key beaches, Florida. A high-accuracy surveying sled, modified after those used by Coastal Engineering Research Center at the Field Research Facility in Duck, North Carolina, was used to measure the nearshore portion of the profile. The bar-berm portion was surveyed by rod and level using standard level surveying procedure with a fully-automated theodolite. Least-squares curve-fitting was applied to reproduce the measured profiles and to obtain the empirical parameters, A_1, A_2, m_2, and x_2. The value of m_1 was determined to be ⅔ based on DEAN (1977).

Scale Parameters A_1 and A_2

A series of empirical predictions was proposed by MOORE (1982) and DEAN (1987; 1991). Their prediction was found to agree well with the regional average profile (Figure 1) and average sediment grain size for Sand Key beaches. The least-squares fit A value is 0.15 $m^{1/3}$, which is essentially the same as the A that is obtained from the average mean grain size (0.33 mm) based on the relationship proposed by MOORE (1982) and DEAN (1987). The average grain size of 0.33 mm

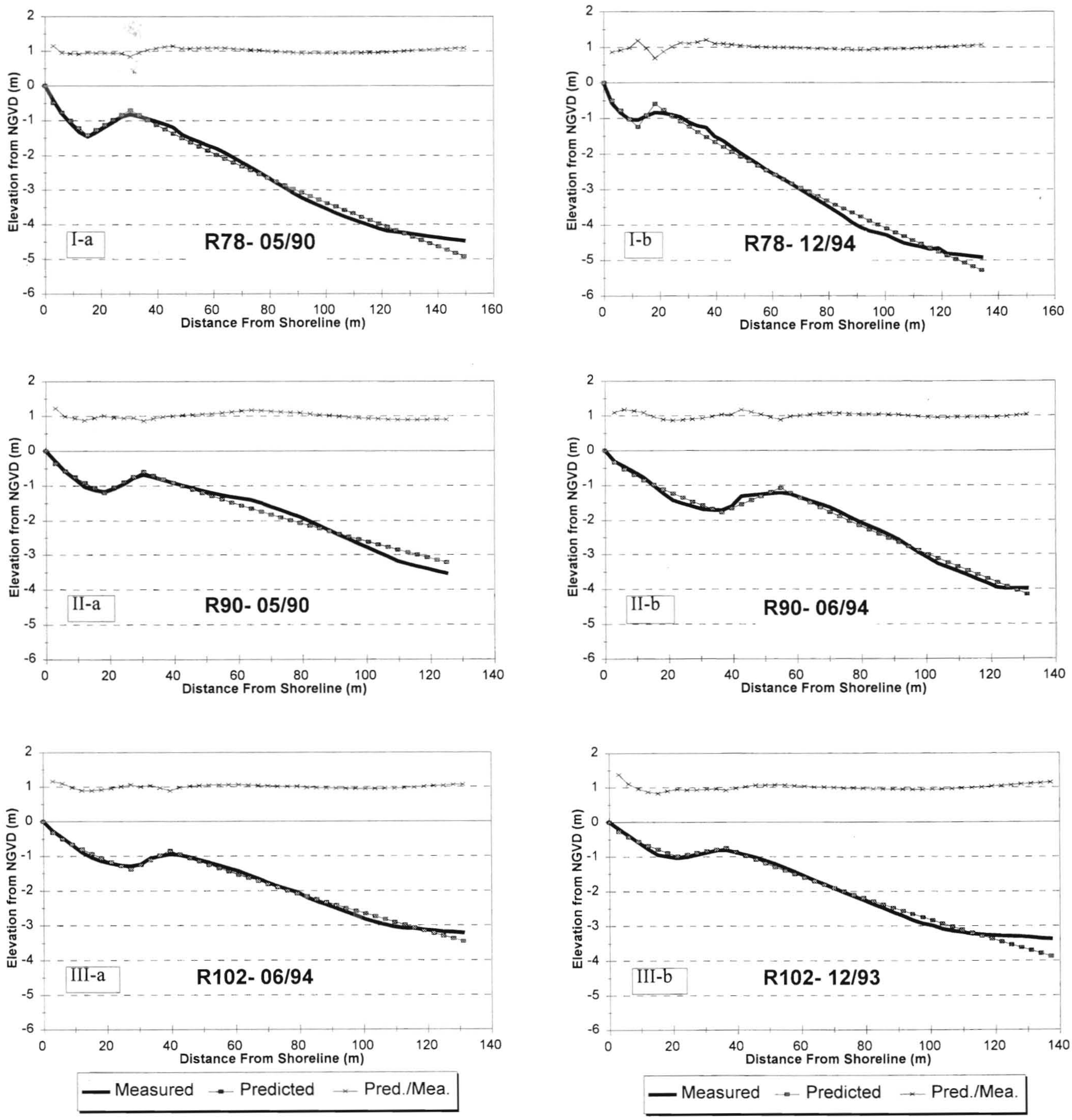

Figure 5. Examples of measured and predicted profiles. I: R78 from Indian Rocks Beach, a) pre-nourishment beach and b) four years after the nourishment. II: R90 from Indian Shores, a) pre-nourishment beach and b) two years after the nourishment. III: R102 from Redington Beach, a) summer profile and b) winter profile. Notice that the ratios between the measured and predicted evaluations are close to 1.

was obtained from 1100 sediment samples collected immediately seaward of shoreline, at −1.0 m, and at −3.7 m throughout the 5-year study period.

Two scale parameters, A_1 and A_2, instead of an overall A, were used in the present 3-segment model. The best-fit A_1 and A_2 values for the 122 measured profiles, including 82 post-nourishment and 40 pre-nourishment profiles, are shown in Figure 7. The inner-surf value A_1 decreases slightly

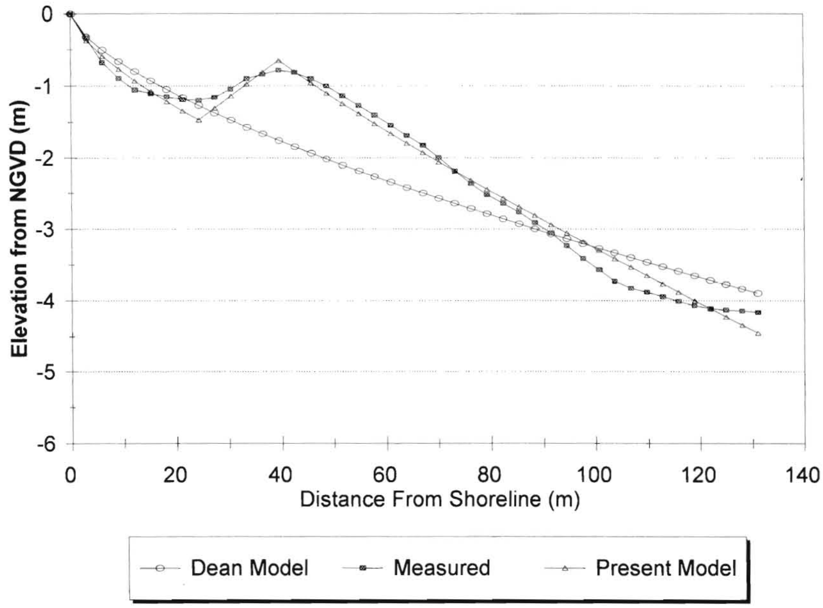

Figure 6. Comparison between DEAN (1977) and the three-segment models. The present model successfully predicted the bar and trough features on a measured profile. The Dean curve here is the best-fit with the regional average profile shown in Figure 3.

to the south on Sandkey. This trend agrees with the general southward decrease of sediment grain size (Figure 8). Higher values of A_2, as compared to the rather constant A_2 value along the rest of Sand Key, were obtained at the northern Indian Rocks beach. These high values are probably caused by the coarser, shelly sediment used to nourish Indian Rocks Beach. The borrow material has as much as 70% shell debris and is coaser than the sand on the pre-nourishment beach. The overall variation of A_2 was less than that of A_1 (Figure 6). This can be explained by the more uniform sediment size in the nearshore region than that in the inner surf zone (Figure 8).

The average of the best-fit A_1 values is 0.19 ± 0.04 $m^{0.3}$ which is larger than the overall A value of 0.15 $m^{0.3}$ for this coast. The average value of the best-fit A_2 is 0.09 ± 0.01 $m^{0.2}$. The slightly different A_1 and A_2 dimensions are caused by the different shape factors, m_1 and m_2, respectively, which are discussed in the following section. This small dimensional difference is neglected in the following discussion because the model is largely empirically based.

The difference between the average A_1 (0.19) and A_2 (0.09) values corresponds with the different grain sizes at different portions of the profile (Figure 8). The average grain size of the sediment in the inner surf zone, including the swash and -1 m samples, is 0.41 mm. The corresponding scale parameter, A_1, obtained from DEAN's (1987) analysis for the inner surf zone is 0.17, slightly smaller than the best-fit value of 0.19. The average grain size of the nearshore portion as represented by samples from -3.7 m is 0.18 mm. The corresponding A value based on DEAN's (1987) analysis is 0.08, almost the same as the average best-fit value of 0.09. The overall agreement between the best-fit A_1 and A_2 values and estimations from the analysis of MOORE (1982) and DEAN (1987) is good. The estimations are applicable to the west-central Florida coast, for both the power function model (Eq. 1) and the three-segment model (Eqs. 3 to 5) proposed in this study.

Shape Parameters m_1 and m_2

The best-fit shape parameter in the inner surf zone, m_1, was found to be close to ⅔. Only 2.5% of the examined profiles have significantly different best-fit m_1 values; therefore, ⅔ is used for the west-central Florida coast. The shape parameter, m_2, for the nearshore portion of the profile was found to be fairly constant ranging from 0.80 to 0.85 (Figure 9). The average m_2 value was 0.82 with a standard deviation of 0.02 (3.0%). The average best-fit m_2 value was slightly larger than the equilibrium energy dissipation (DEAN, 1977) value of 0.67. The difference is probably caused by the fact that the shape of the nearshore portion of the profile is control by both m_2 and the intercept distance, x_2, which is discussed in the following section.

Intercept Distance x_2

The intercept distance (x_2) has a significant control on the shape of the nearshore portion of the profile. Given the same values of all the other variables in Equation 5, a larger x_2 results in a shallower water depth for the nearshore portion, and a smaller x_2 results in a deeper water. This distance does not have any morphological meaning and is introduced for the convenience of modeling. The relationship between x_2 and various morphological parameters, such as the distance from shoreline to the trough bottom, x_{tr}, the distance from shoreline to the bar top, x_{bt}, and the distance from shoreline to the closure depth, x_{cd}, were examined. A fairly constant ratio was found between the best-fit x_2 values and the distance from shoreline to the bar top, x_{bt}, (Figure 10). The average of the x_2/x_{bt} is 0.652 with a standard deviation of 0.076 (11.7%). The intercept distance, x_2, can therefore, be estimated from the position of the breakpoint-bar as

$$x_2 = 0.652x_{bt} \tag{6}$$

The distance from the bar top to the shoreline, x_{bt}, is one of the two fundamental input parameters that the three-segment model requires.

In summary, the three-segment model developed in this study demonstrates promising potential in reproducing beach profiles with bar and trough features. The model is more flexible and actualistic than the monotonic one-segment models. The knowledge learned from previous studies of DEAN (1977; 1987) and MOORE (1982) on scale and shape parameters was found to be applicable in the present model for the west-central Florida coast. The following empirical formulas are recommended for the west-central Florida barrier coast
inner surf zone:

$$h(x) = 0.19x^{2/3} \quad \text{for} \quad 0 < x \leq x_{tr} \tag{7}$$

landward barslope:

$$h(x) = h_{tr} + \frac{h_{bt} - h_{tr}}{x_{bt} - x_{tr}}(x - x_{tr}) \quad \text{for} \quad x_{tr} < x < x_{bt} \tag{8}$$

nearshore:

$$h(x) = 0.09(x - 0.652x_{bt})^{0.82} \quad \text{for} \quad x_{bt} \leq x < x_{cd} \tag{9}$$

The water depths at the trough bottom (h_{tr}) and bar top (h_{bt}) used in Equation 8 are obtained from Equations 7 and 9, respectively.

Information on sediment grain size and its distribution is helpful in determining the scale parameters, A_1 and A_2. The least-squares fit A_1 value of 0.19 $m^{0.3}$ and A_2 value of 0.09 $m^{0.2}$ are recommended for west-central Florida coast. Examples of the measured, best-fit, and predicted profiles from Equations 7 through 9 are shown in Figure 11. The generalized three-segment model (Eqs. 7 to 9) describes the bar and trough features reasonably well. The general model tends to under-predict the water depth at the northern Indian Rocks Beach and over-predict the depth at the southern Redington Beach due to the slightly different A values caused by variation in sediment grain sizes which are coarser in the north and finer in the south. Proper adjustments of A_1 and A_2 values, around 0.19 and 0.09, respectively, based on in-situ sediment size will improve the accuracy of the three-segment model.

DISCUSSION

Compared to the one-segment monotonic model of BRUUN (1954) and DEAN (1977), which only requires the input of sediment grain size for estimating the scale parameter, A, the present three-segment model requires more information. Included are the distance from the shoreline to the trough bottom, x_{tr}, to separate the inner surf zone from the landward side of the bar, and the distance from shoreline to bar top, x_{bt}, to separate the nearshore portion from the landward side of the bar. The distances x_{tr} and x_{bt} can be easily measured in the field and obtained from various sources such as aerial photos and nearshore bathymetric maps. The present model also requires information on sediment grain size and its distribution. The two grain-size related scale parameters, A_1 and A_2, instead of one A as in BRUUN (1954) and DEAN (1977) model, make the three-segment model potentially more flexible in reflecting the influence of varying sediment size on the shape of the profile.

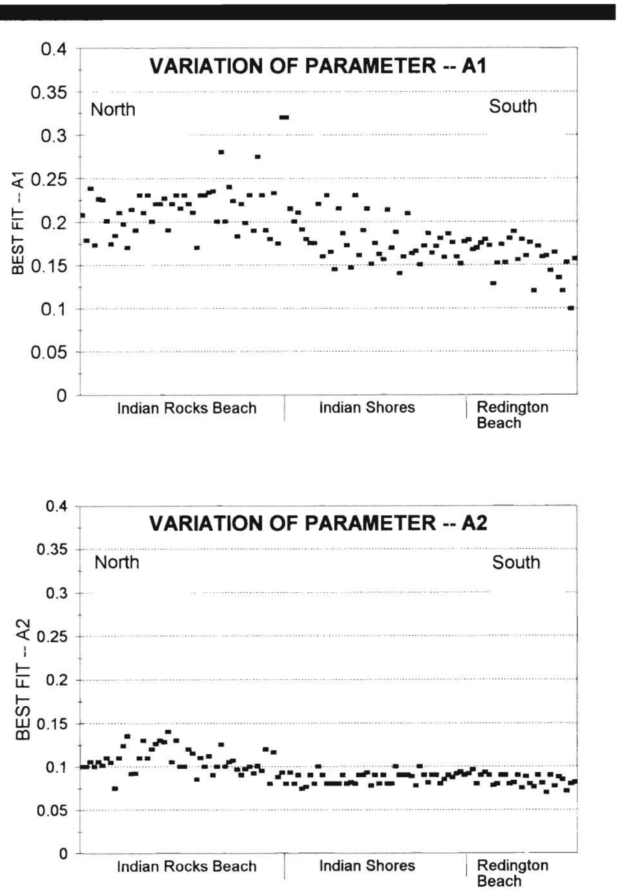

Figure 7. Variations of parameters A_1 and A_2 within the study area. Notice the southward decrease, which is consistence with the trend of sediment size.

The scale parameters, A_1 and A_2, obtained from the curve-fitting in this study are in reasonable agreement with the grain-size relationship developed by DEAN (1987) and MOORE (1982). The A_1 and A_2 values obtained by INMAN *et al.* (1993) from the southern California coast varied from 0.19 to 3.10 and from 0.23 to 3.87, respectively (INMAN *et al.*, 1993). The average best-fit A_1 value was 0.78, 26% lower than the average A_2 value of 1.06. The A value obtained by BRUUN (1954) from Mission Bay, California, differed significantly from a summer value of 0.03 $m^{1/3}$ to a winter value of 0.14 $m^{1/3}$. The relationship between A values and sediment grain size was not obvious for the southern California study by INMAN *et al.*

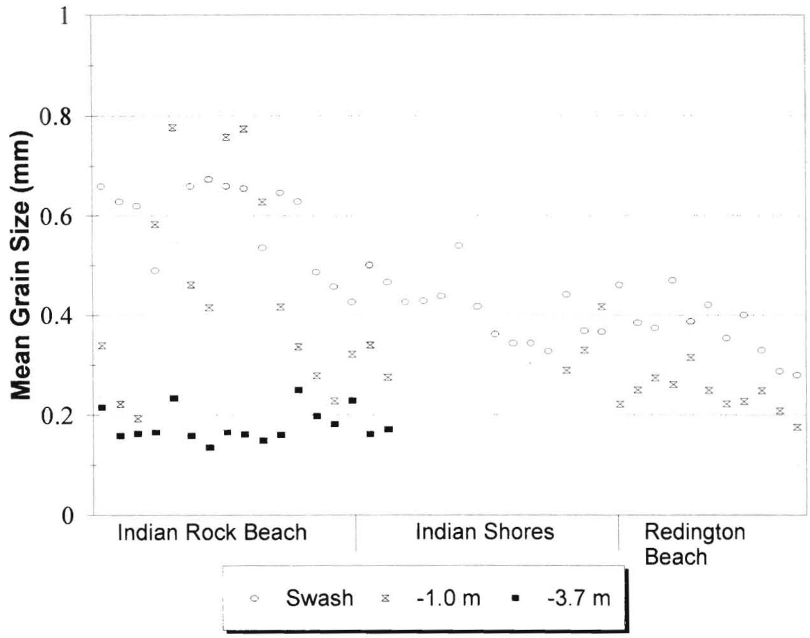

Figure 8. Sediment grain size distribution across the Sand Key beaches. The grain sizes are time-series averages of 18 to 27 samples at each site from 1990 to 1993. The −3.7 m samples, representing the nearshore sediment size, from Redington Beach were discarded because they were below the closure depth. The sediment size in the inner surf zone is represented by the average of the swash and the −1 m samples.

(1993). Unlike the studies of DEAN (1977), BODGE (1992), and the present study, which started at mean-sea-level, the analysis of INMAN *et al.* (1993) included a considerable portion of the dry beach, up to 5.6 m above MSL. The dimensions of the *A* values from INMAN *et al.* (1993), which were approximately $m^{0.6}$, are rather different from the *A* dimensions in the present study (approximately $m^{0.3}$ for A_1 and $m^{0.2}$ for A_2) and that in DEAN's (1977) analysis ($m^{0.3}$). The *A* values are not directly comparable due to the different dimensions caused by different values of the shape parameter, *m*.

The average values of the shape parameters, m_2, and m_2, were found to be 0.41 and 0.36, respectively, from INMAN *et*

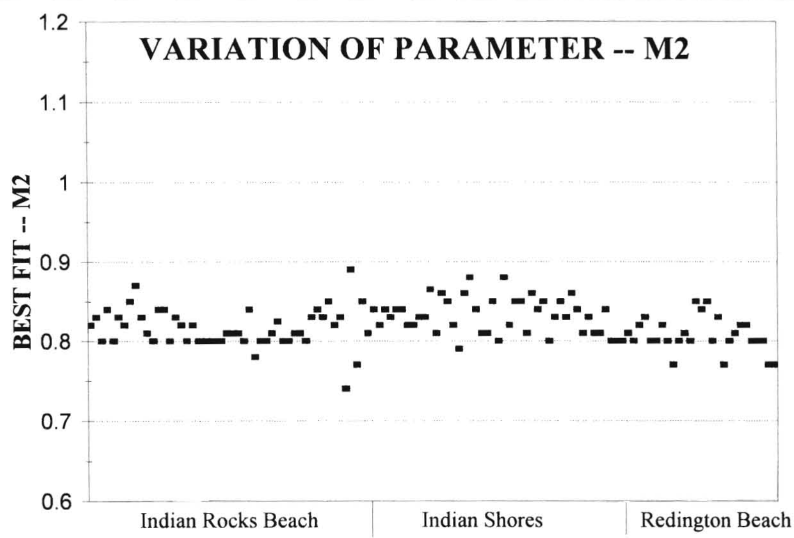

Figure 9. Variation of the shape parameter, m_2 in the study area.

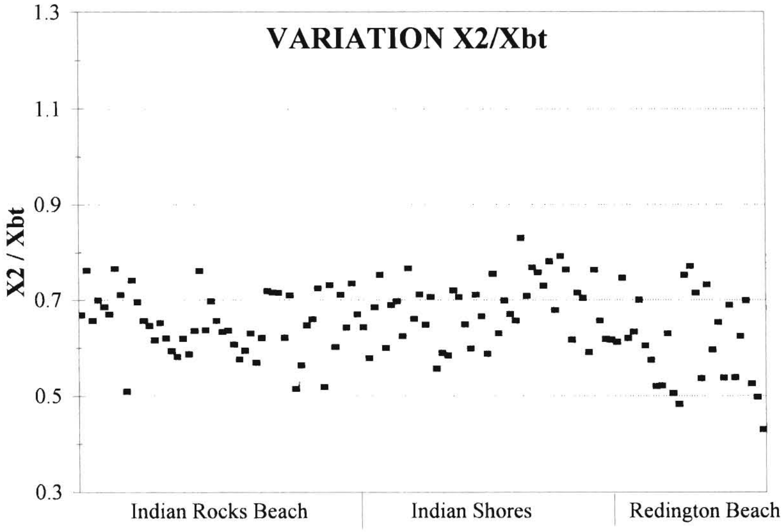

Figure 10. Variation of the ratio between the intercept distance, x_2, and the distance from shoreline to bar top, x_{bt} through the study area.

al. (1993). The value 0.4 is consistent with DEAN's (1977) analysis assuming a uniform average longshore shear stress or a uniform average energy dissipation rate per unit surface area. DEAN (1977) concluded that the uniform average wave energy dissipation rate per unit water volume, which yielded the m value of ⅔, was the governing mechanism. BOWEN (1980), utilizing the transport relationship of BAGNOLD (1963), obtained zero local transport with m=0.4 assuming the near-bottom current was an oscillatory term that included a second-order Stokes perturbation. In the present study, the m_1 value of 0.67 is considerably larger than the southern California values of 0.4. No attempt was made in this study to explore the mechanism that controls the value of m_2 which is twice as high as the value obtained by INMAN *et al.* (1993). The situation of m_2 in determining the shape of nearshore portion is further complicated by the existence of the intercept distance x_2.

In summary, the three-segment model utilized existing knowledge on beach profile modeling and is capable of reproducing the barred profile along the west-central Florida coast. The empirical scale and shape parameters obtained are in good agreement with the analysis of DEAN (1977; 1987; 1991), which were based mainly on data from the U.S. Atlantic and Gulf coasts. The parameters obtained from the Pacific coast in southern California are significantly different from those of this study as well as from those of DEAN (1977; 1987). The winter and summer beach cycles which were well documented at southern California beaches are not distinctive along the west-central Florida coast. Further study is needed to understand the influences of the different regional geomorphic and oceanographic settings on the shape of the beach profiles.

SUMMARY AND CONCLUSIONS

The bar and trough are important portions of a nearshore equilibrium system that respond to both short-term and long-term changes of wave conditions. It is important for beach profile models to incorporate these common features.

A barred beach profile can be described reasonably well with three segments: inner surf zone, landward slope of bar, and nearshore region. The commonly used and well established power function can be used to describe the inner surf zone and nearshore region. The landward side of the bar can be described by a plane slope. Compared to the one-segment monotonic models, the three-segment model is more flexible and capable of reproducing more complicated changes of water depth and beach slope. The relationship between the scale parameters (A_1 and A_2) and sediment grain size, and the consistency between the inner surf zone shape factor (m_1 = ⅔) and uniform wave energy dissipation per unit water volume are applicable to the present model. The model requires the input of two elements of basic information for the subdividing of the beach profile: the distances from the shoreline to the trough bottom (x_{tr}), and to the bar top (x_{bt}). This information can be obtained fairly easily through field measurements as well as from aerial photos and bathymetric maps.

A set of empirical formulas is recommended for the beach-profile prediction along the west-central Florida coast. Comparison with the studies from southern California indicates that the empirical parameters may vary significantly due to different geological and oceanographic conditions. Understanding the regional geological and oceanographical control may be critical in determining the empirical parameters and the applicability of the present model.

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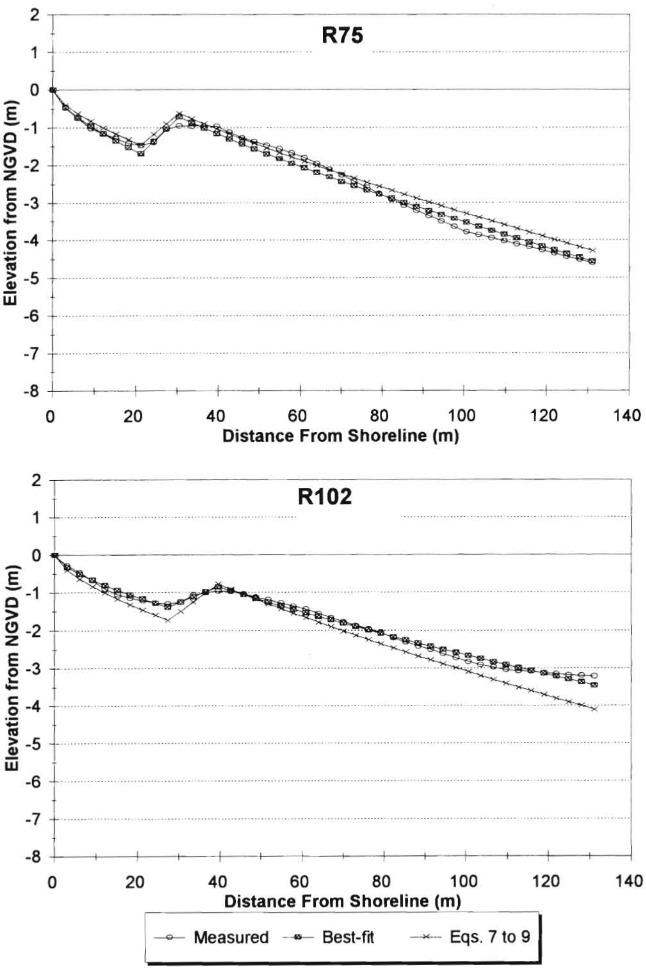

Figure 11. Examples of measured, best-fit, and predictions from the generalized model. Bar and trough features are well reproduced. Notice that the water depth is under-estimated for the northern R75 and over-estimated for the southern R102 by the generalized model.

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