



REPLY

Reply to: Houston, J.R., Rejoinder to: Pilkey, O.H., Young, R.S., Thieler, E.R., Jacobs, B.S., Katuna, M.P., Lennon, G. and Moeller, M.E., 1996. Reply to Houston, J.R., A discussion of the Generalized Model for Simulating Shoreline Change (GENESIS). *Journal of Coastal Research*, 12(4), 1044-1050; *Ibid.*, 14(3), 1170-1173.

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INTRODUCTION

In his rejoinder to our reply (PILKEY *et al.*, 1996) of his discussion of YOUNG *et al.* (1995), HOUSTON (1998) states that we "provide virtually no concrete criticism that GENESIS developers can address" (p. 1173). On the contrary, we believe that we offered very fundamental criticisms of GENESIS that need to be answered. In this reply to HOUSTON (1998), we reiterate eight criticisms of GENESIS that form the basis of the criticism in our original paper (YOUNG *et al.*, 1995). If deterministic numerical models used in beach design are to have credibility, it is essential that fundamental criticisms such as ours be addressed. We ask that Houston respond to these questions as the first step in a dialogue between model proponents and critics. Such a dialogue, centered around the widely used GENESIS shoreline change model (HANSON and KRAUS, 1989; HANSON, 1989), should be useful for coastal managers who see model applications on an almost daily basis and who apply models with little understanding of how they work. We feel that our criticisms are fair, objective, and worthy of a response.

The same eight questions apply to most models used to predict beach behavior, including SBEACH (LARSON and KRAUS, 1989).

EIGHT QUESTIONS

Wave Parameters

Mean wave height and direction are critical for modeling of beach behavior. Yet, as pointed out in the GENESIS technical manual (HANSON and KRAUS, 1989), good wave data are rarely available. Two waves of the same height, period,

and direction do not necessarily have the same effect, depending on beach state, sediment sorting, sand supply, and other factors. Assuming good wave data were available, *how do you know which average wave characteristics are useful in a GENESIS model run to predict the behavior of a given beach?*

Shoreface Character

The GENESIS model assumes that the shoreface is composed of a thick, homogeneous layer of sand. It also assumes a shoreface surface based on an equilibrium profile shape. Recent studies, of East Coast shorefaces (RIGGS *et al.*, 1995; THIELER *et al.*, 1995; 1998; SCHWAB *et al.*, 1997), however, indicate increasingly that most shorefaces are sediment-starved, and that shoreface shape is controlled by a widely varying geologic framework ranging from modern inlet-fill to well-indurated Tertiary limestone. In addition, the concept of profile of equilibrium has been called into question (PILKEY *et al.*, 1993; RIGGS *et al.*, 1995; THIELER *et al.*, 1995). Even on relatively sand rich shorefaces, offshore bars are responsible for variations in the volume of sand transported on the upper shoreface (WRIGHT and SHORT, 1983; HOLMAN, 1995); shell lags, organic mats, and even wave-induced stresses may inhibit sand transport in fairweather and delay the onset of sediment transport during storms (WRIGHT, 1989; WRIGHT *et al.*, 1991; 1994; 1997). *How do you rationalize the GENESIS assumption of a smooth equilibrium profile without geologic control, offshore bars, or sediment variability?*

Closure Depth

GENESIS assumes a closure depth (or depth beyond which no sediment is transported in significant volumes). We find

no oceanographic basis for the existence of a closure depth. Rather the geologic literature is full of data suggesting significant sediment transport from shallow into deep water and *vice versa* (see NUMMEDAL, 1991; PILKEY and FIELD, 1972 as examples). Current-meter studies (WRIGHT *et al.*, 1991) indicate such a dividing line between the shoreface and the inner shelf does not exist. The seaward transport of beach nourishment sediment has been observed to depths well beyond the design closure depth at a number of beaches (PEARSON and RIGGS, 1981; THIELER *et al.*, 1994; REED and WELLS, in press). At Folly Beach, South Carolina, the subject of much of the rejoinder in question (HOUSTON, 1998), substantial quantities of nourishment sediment are being transported onto the inner shelf beyond the presumed closure depth (THIELER *et al.*, in press). *What is the field evidence for the existence of a closure depth, as used in GENESIS, as a limit of significant offshore sediment transport?*

Mean and Combined Flows

WRIGHT *et al.* (1991) note the existence of at least five different types of mean flows on the shoreface. These currents often interact with wave-induced currents and are responsible for sediment transport, onshore and offshore, even in fair weather (SWIFT, 1976; GRANT and MADSEN, 1979; CACCHIONE and DRAKE, 1990; PILKEY *et al.*, 1993; WIBERG *et al.*, 1994). None of these currents are considered in GENESIS. *Because mean and combined flows are not considered in GENESIS, how do you discount their importance in sediment transport?*

Uncertainty

GENESIS is a deterministic model. Output quantities are provided without error bounds. Yet, model users need to know the possible errors or uncertainties in the model output. It is in the public's interest to be made aware of the scientific uncertainty of projects funded by public monies. This is especially true because the durability of coastal engineering projects like beach nourishment is often determined in large part by randomly occurring, but inevitable, storms (LEONARD *et al.*, 1990). Further, the nearshore oceanographic system is extremely complex and exhibits chaotic behavior. *How can GENESIS provide useful answers for coastal managers if the error bounds of the model output are unknown?*

Averages

GENESIS model parameters and results rely heavily on averaged values. Averaging, however, removes extreme events from either end of the spectrum and extreme events are certainly, on some beaches, responsible for most of the rapid and large changes. The use of averages denies the significance of the natural variability of the nearshore system (NICOLIS and NICOLIS, 1991). *How do you justify the widespread use of average values (e.g., wave characteristics, grain size, nearshore slope) in GENESIS?*

Storms

Storms and storm-related processes are important, if not critical, in the evolution of most beaches. Storm processes are

numerous, including overwash, eolian transport, nearshore and inner shelf sediment transport by up- and down-welling, rip currents, storm surge ebb, *etc.* Storms of different intensity and from different directions can have widely varying impacts on the same beach. *How can a model such as GENESIS omit a realistic storm climate in predicting beach behavior?*

Field Data

The successful use of any model of earth surface processes requires good input data. As pointed out repeatedly by the GENESIS technical manual (HANSON and KRAUS, 1989), however, adequate data from a given field site are rarely available. Model-required data such as mean wave characteristics, groin permeability, nearshore bathymetry, shoreface sediment characteristics, and closure depth are difficult to obtain. Even if the model was able to represent reality accurately, the problem can be summed up in the old adage, "garbage in, garbage out." *In view of the great uncertainties concerning all input data and boundary conditions that might affect a GENESIS model run, how can one expect a physically reasonable answer from the model?*

CLOSURE

These eight questions are a distilled reiteration of the original criticisms of the GENESIS model from YOUNG *et al.* (1995). Although that paper has been much discussed within the pages of this journal, the fundamental questions of model usefulness and accuracy have never been answered or discussed. We desire a meaningful dialogue regarding the evidence behind coastal modeling assumptions and we believe these eight questions are a good place to start.

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DISCUSSION AND REPLY

Reply to: Houston, *Journal of Coastal Research*, 15(4), Rejoinder to: Pilkey, O.H.; Thieler, E.R.; Young, R.S., and Bush, D.M., 1999.

Reply to: Houston, 1999, Rejoinder to: Pilkey, O.H.; Young, R.S.; Thieler, E.R.; Jacobs, B.S.; Katuna, M.P.; Lennon, G., and Moeller, M.E., 1996. Discussion of Young, R.S.; Pilkey, O.H.; Bush, D.M., and Thieler, E.R., 1996.

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We offer the confused reader of this reply a brief summary of events. The original paper (YOUNG *et al.*, 1995), the subject of this series of replies and rejoinders (HOUSTON, 1996, PILKEY *et al.*, 1996, HOUSTON, 1998, PILKEY *et al.*, 1999, HOUSTON, *et al.*, this issue) was a detailed criticism of the mathematical model GENESIS (HANSON and KRAUS, 1989) which is commonly used to predict the behavior of beaches for coastal engineering purposes. In his original discussion of our paper, HOUSTON (1996) chose not to address our detailed criticisms of the GENESIS model, but rather, he chose to criticize our claim that the beach nourishment project at Folly Beach, South Carolina was an example of the failure of GENESIS.

We have responded once to this assertion (PILKEY *et al.*, 1996), and we find continued haggling over the success or failure of the Folly Beach project to be pointless. We have all made our arguments and it is obvious that we disagree. Even if one could argue that the Folly Beach project has performed as designed (and we believe it has not), that still would not prove the veracity of GENESIS. In the original paper (YOUNG *et al.*, 1995) we cite several other examples of the misuse of GENESIS.

We must return the debate to the larger question of the physical accuracy of the GENESIS model. The model's underlying assumptions are not based in physical reality, the model's required input data are almost never available, and most model values are averaged to the point of being meaningless. In our last rejoinder (PILKEY *et al.*, 1999), we posed a series of questions that we believe would be a good starting point for a serious and thoughtful discussion of the GENESIS model. However, our efforts to redirect the debate to the heart of the matter have elicited no response from Houston

or the model formulators. We can only assume, then, that our criticisms are valid. The importance of GENESIS far transcends our petty disagreements; our seemingly interminable, did not-did too-did not-did too exchange. GENESIS and models like it may well become mainstays of coastal engineering in the US and as such is worthy of vigorous, open debate. Our criticisms are worthy of response. The following very recent example of GENESIS application clearly demonstrates why a dialogue is sorely needed.

The U. S. Army Corps of Engineers has recently released a General Design Memorandum (USACE, 1999) for a proposal to build jetties at Oregon Inlet, North Carolina. Prediction of the success of jetties and the critical proposed sand bypass system is predicated entirely upon GENESIS output. In applying the model (USACE, 1999), the Wilmington District of the Corps makes all the assumptions and applications that we criticize (YOUNG *et al.*, 1995). Among other GENESIS derived conclusions is the assertion that the wier jetty will pass exactly the amount of sand furnished to the system for the foreseeable future.

The initial cost of the jetty project is around \$90 million. It is a major project by any measure. If GENESIS is wrong, either the costs of the project will be much higher or the environmental damage downdrift to the Pea Island National Wildlife Refuge, the Cape Hatteras National Seashore, and four coastal communities will be large. Or both. Our questions that we posed to Houston (PILKEY *et al.*, 1999) are a first step in debating the validity of this hugely important model.

The implications are broader than beach behavior. Called into question here are all deterministic engineering models of earth surface processes that ask the very specific engi-

neering questions, where, when, and how much? This is very different than using an earth surface processes model for an academic purpose asking a why or how type question.

Here is a list of the 8 questions (abbreviated) we asked Houston (PILKEY *et al.*, 1999). We would be pleased to have response from anyone, pro or con.

- (1) Assuming good wave data were available, how do you know which average wave characteristics are useful in a GENESIS model run to predict the behavior of a given beach?
- (2) What is the field evidence of the existence of a closure depth, as used in GENESIS, as a limit of significant offshore sediment transport?
- (3) Because mean and combined flows [on the shoreface] are not considered in GENESIS how do you discount their importance in sediment transport?
- (4) How can GENESIS provide useful answers for coastal managers if the error bounds of the model output are unknown?
- (5) How can a model such as GENESIS omit a realistic storm climate in predicting beach behavior?
- (6) How do you justify the widespread use of average values (e.g., wave characteristics, grain size, nearshore profile shape) in GENESIS?
- (7) How do you rationalize the GENESIS assumption of a

smooth equilibrium profile without geologic control, offshore bars, or sediment variability?

- (8) In view of the great uncertainties concerning all input data and boundary conditions [listed in the GENESIS manual by HANSON and KRAUS, 1989, and discussed in YOUNG *et al.*, 1995] that might affect a GENESIS model run, how can you expect a physically reasonable answer from the model?

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REPLY

Rejoinder to: Pilkey, O.H.; Thieler, E.R.; Young, R.S., and Bush, D.M., 1999. Reply to Houston, J.R., 1998. *Journal of Coastal Research*, 14 (3), 1170–1173, Summer 1998. Rejoinder to: Pilkey, O.H.; Young, R.S.; Thieler, E.R.; Jacobs, B.S.; Katuna, M.P.; Lennon, G., and Moeller, M.E., 1996. *Journal of Coastal Research*, 12 (4), 1044–1050, Fall 1996. Reply to: Houston, J.R., 1996, Discussion of Young, R.S.; Pilkey, O.H.; Bush, D.M., and Thieler, E.R., A Discussion of the Generalized Model for Simulation Shoreline Change (GENESIS). *Journal of Coastal Research*, 12 (4), 1038–1043, Fall 1996. *This Volume*.

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INTRODUCTION

HOUSTON (1996) noted that YOUNG *et al.* (1995) cited the Folly Beach beach-nourishment project, South Carolina, as an example supporting their claim that the shoreline-response model GENESIS failed in a practical application. HOUSTON (1996) said, "... the GENESIS developers can do a much better job than I debating the efficacy of GENESIS," but pointed out that statements by YOUNG *et al.* (1995) concerning the performance of the Folly Beach project were "simply not true" and provided measurements and extensive photographs showing this to be the case. The photographs presented by HOUSTON (1996) looked down the beach's length at a landmark and covered the entire project so the reader could obtain a complete view of the project (there are over 120 photographs). PILKEY and DIXON (1997) presented only two photographs that showed erosion on short stretches of beach that HOUSTON (1996) had already pointed out as having erosion problems, and they then concluded, "Both their photos and ours are useless as evidence of the overall success of the Folly Beach project." PILKEY *et al.* (1996) presented measurements they made at the Folly Beach project and repeated their claims that the project performed poorly and GENESIS predictions were inaccurate. However, HOUSTON (1998) showed, these measurements agreed with measurements and photographs in HOUSTON (1996), and all directly contradicted statements in YOUNG *et al.* (1995) and PILKEY

et al. (1996) concerning the project's performance and GENESIS predictions.

DIALOGUE IS NOT POSSIBLE WHEN FACTS ARE IGNORED

Unfortunately, PILKEY *et al.* (1999) did not submit a timely reply to HOUSTON (1998), so their reply was not published in the same edition (HOUSTON, 1998, was submitted to the *Journal of Coastal Research* in March, 1997). Had their reply been published with HOUSTON (1998), the reader would have clearly seen their reply was completely unresponsive to the discussion of HOUSTON (1998). The key sentence in HOUSTON (1998) was, "It would be difficult to debate the subtleties of models such as GENESIS when agreement cannot even be reached on simple facts relating to the Folly Beach Project—the only application of GENESIS that YOUNG *et al.* (1996) criticize." PILKEY *et al.* (1999) ignore the discussion of HOUSTON (1998) except for part of one sentence and never address the central topic of the discussion, the performance of the Folly Beach project and predictions made by GENESIS relating to the project. PILKEY *et al.* (1999) have chosen a clever but transparent debate tactic—ignore facts raised by your debate opponent and strike out in directions unrelated to the debate. I have presented extensive measurements and photographs of the Folly Beach project and shown they are supported by measurements presented by PILKEY *et al.* (1996).

The measurements (including those of PILKEY *et al.*, 1996) and photographs all contradict key statements made by YOUNG *et al.* (1995) and PILKEY *et al.* (1996) concerning the performance of the Folly Beach project and the GENESIS model. Rather than simply admit their statements were incorrect, PILKEY *et al.* (1996) obfuscated, and PILKEY *et al.* (1999) change the subject. These may be winning debate tactics, but dialogue and the truth are the victim.

Dr. Pilkey and his colleagues have published several papers criticizing coastal models. They have lamented that modelers have not engaged in dialogue with them, and PILKEY *et al.* (1999) call for "dialogue between model proponents and critics." Is dialogue really possible when Dr. Pilkey and his colleagues will not accept measurements by made by others, their own measurements, and eyewitness reports in the form of photographs of the condition of the Folly Beach project? If we cannot agree on simple facts supported by overwhelming data, the debate is simply not about trying to determine scientific truth.

CONCLUSION

HOUSTON (1996) and HOUSTON (1998) presented measurements and extensive photographs of the Folly Beach project and showed this information was supported by measurements presented by PILKEY *et al.* (1996), and all evidence and analysis contradicted statements made by YOUNG *et al.* (1995) and PILKEY (1996) relating to the condition of the Folly Beach project and performance of the GENESIS model. Rather than admit they were wrong, PILKEY *et al.* (1999) ignore the discussion of HOUSTON (1998). Repeating the key conclusion of HOUSTON (1998), "It would be difficult to debate subtleties of models such as GENESIS when agreement can-

not even be reached on simple facts relating to the Folly Beach Project—the only application of GENESIS that YOUNG *et al.* (1996) criticize."

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