

Nearshore Sediment Transport Studies

By James R. Allen

The beach is the fundamental resource of most of our National Seashores in terms of visitor enjoyment, due importantly to its role as the principal locus of ocean energy dissipation. The beach is a unique but poorly understood habitat in itself, an important media for nutrient exchange between terrestrial and marine ecosystems, and the main driver of onshore ecological zonation.

Improvement of our knowledge of the natural processes driving beach behavior from the outer bar to (and sometime through) the dune, benefits recreation and resource managers as well as interpreters. While many parks have some documentation of past shoreline changes, comprehension of why some areas differ from others is often elusive. In many instances the answers lie offshore in the sediment transport link between bottom topography and wave energy dissipation. Many gaps remain in our understanding of when, where, and why beaches change their form.

Park administrators face additional problems arising from the intervention of society with the natural coastal processes. Coastal environs likely are the most energetic, dynamic, and changeable found on the earth, yet people continue to impose static plans for land use, support structures, and resource management. Many of these actions are external to the parks and are difficult to prevent because often we are unable to conclusively document a causal relationship. Sometimes we are simply overwhelmed by other needs of society.

The impacts upon park resources are extremely costly to mitigate in order to preserve or restore resources and retain visitor access to them. Every Seashore along the Atlantic and Gulf coasts suffers from threats due to coastal manipulation in one (usually more) form or another. The specter of accelerated sea level rise also clouds our vision of optimal seaside management.

Two ongoing studies of the nearshore zone with different management goals are: (1) the beach erosion that threatens communities at Fire Island National Seashore (FIIS) to better understand the natural role of nearshore energy dissipation, and (2) investigation of an altered system to mitigate the harm thought to be caused by an external structure at Riis Beach, Gateway NRA.

Fire Island National Seashore

The shoreline on western FIIS is retreating on bay and ocean sides in response to storms acting on a rapidly rising sea level. This is perceived as extremely hazardous to life and property in the 17 communities intercalated among the park-administered lands. Such powerful forces demand protection.

Recently we discovered that beach and dune erosion during storms is often localized and spatially periodic. Understanding why this occurs is required before we can evaluate protection schemes proposed by others or advise property owners and permitting agencies on permissible actions, and effectively manage our own resources. For one week in each of the past three years, Dr. Norbert Psuty (Rutgers University) and I have been studying a persistent beach re-entrant at Old Inlet. The experiments had extensive support from FIIS personnel. (J. Hauptman, D. Weir,

A. O'Connell, J. Northup, D. Griesse, R. Stavdal, S. Singler, M. Tripi, J. Clarke, N. Howell, and B. Fulsom deserve special thanks).

In each field season, several times per day, we simultaneously deploy electromagnetic, bi-directional current meters 0.1m above the bed (on sensor mounts built by Tripi) on the longshore bar by SCUBA divers, with instrumentation on the park's ISLAND QUEEN, and in the inner surf zone, with instrumentation on the beach, to measure aspects of the near-bottom velocity field. The sensors are cabled to the support locations where the 18 minute records of data sampled at 0.2s have been stored on strip-chart analogue recorders for subsequent digitizing, (this year all data will be directly logged in digital form), reduction and analysis. Both bedload and suspended sediment traps were used to measure sediment transport. Beach surveys were extended to depths of 9m, the local limit of sediment exchange, using the QUEEN'S recording echosounder.

Simply put, we measure the processes and responses taking place but the analysis and correlation are most difficult. Obtaining satisfactory results has been tedious because of the need for extensive field training, refinement of techniques and instrument design in the face of highly energetic surf, electronics failures, and scheduling constraints.

Initial results indicate, rather surprisingly, that there is a flushing of very high sediment concentrations in periodic bursts out of the surf zone through the gap in the longshore bar. The inshore and bar stations show a dominance of incident waves (5-10s) with a secondary but quite small subharmonic excitation (usually 12-20s); the hole in the bar is usually dominated by the incident wave oscillations but there is a strong secondary excitation directing the sediment bursts offshore at 50-80s intervals.

These rip current features have not been identified before. Even though the bursts are lower in energy and frequency than the incident waves, the 50-fold increase in sediment concentration results in the phenomenon accounting for more than 50 percent of the total cross-shore sediment movement. Other investigators also are finding that these long period waves (known as infragravity waves to scientists and "surf beat" by surfers) sometimes may contain even more energy than the more visible incident waves.

Our evidence suggests that infragravity waves may control the regular pattern, i.e. the repeated embayments in the shore, often noticed with beach erosion by generating edge waves along the shore.

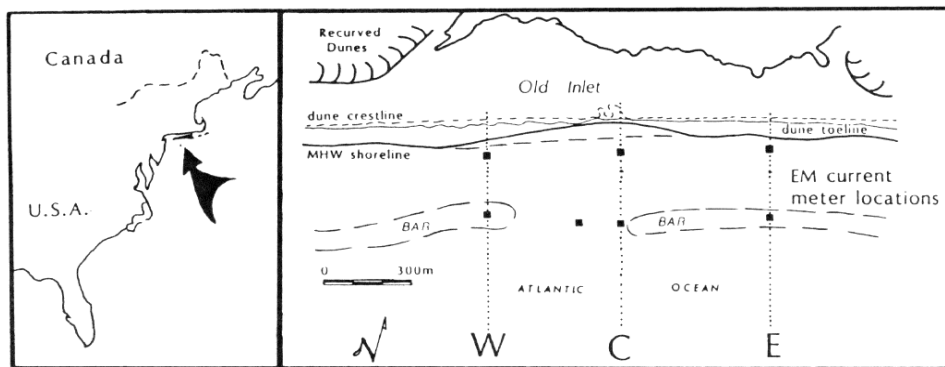
Edge waves are regular undulations of the sea surface formed by the harmonic or subharmonic resonance of reflected energy of incident or infragravity waves. They allow for higher incident wave runup hence greater erosion at the edge wave crest and thus explain why there can be alternating sequences of untouched versus heavily eroded dunes and why the nearshore bar deforms in a similar pattern during storms. Whether the *a priori* bar configuration controls the infragravity forced edge waves or whether the bar is the response to the sea-state process remains unknown at present because we have yet to detect the edge wave. Nevertheless, we do have the appropriate energy source frequency to generate the documented shoreline response if we assume edge wave theory is correct.

Now we think we know how even small storms can cause extreme beach erosion in restricted locales where structures and lives may be threatened. Among the many important implications are that the erosional re-entrants are deterministic – not randomly occurring – and therefore should be predictable; they offer a means by which even small storms can have extreme event impacts in restricted locales; they can penetrate even the widest beaches at Fire Island overnight. Thus wide beaches and artificial dunes are illusory protectors – indeed any small protection scheme is likely to fail in their presence.

These erosion sites can be quite vexing to some parks because ORVs are forced into the dunes to safely pass the unpredictable obstacle. This information is especially advantageous to park management in advisory sessions with communities on the futility of many proposed erosion protection schemes and in designing longer-term solutions such as placing all structures on suitable high pilings. Appropriate acquisition strategies must be developed and implemented when individual properties are lost.

Riis Park, Breezy Point Unit, Gateway NRA

Erosion at Riis Park threatens the Bathhouse which is on the National Historic Register and houses many support functions including concessions. The narrowed beach also limits the space available to the two million users during the summer months. Again, storms and sea level rise, combined with a sediment supply deficit, are the underlying causes of a shoreline retreat which has been addressed by the construction of an 8-mile long groin field in this century. The erosion rate increased drastically in the last five years, just after a large groin was constructed at the eastern (or



Old Inlet, Fire Island National Seashore study site location and data collection transects. Plan from aerial photo of April 9, 1984.

updrift in terms of the net sediment transport direction) boundary of the park.

Mitigation of any negative impacts of the groin was assured by the Corps of Engineers prior to construction but they now deny any association of the accelerated erosion with their structure. NPS speculation is that the groin deflects a substantial portion of the sand moving alongshore out onto a longshore bar and thence past the Bathhouse locale before returning to the recreational beach, effectively starving the recreational beach of sand. Emergency appropriation of \$1 million was needed in 1986, for NPS inclusion in an adjacent beach nourishment project by the Corps, to provide limited site protection.

A research project to document the pathways of sediment transport around the groin was initiated in the fall of 1986 with the aid of Dr. Karl Nordstrom and graduate students from the Rutgers NPS/CRU, and Drs. Doug Sherman and Bernie Bauer, Univ. of Southern California. For a week in October and another week in November, we conducted beach profiles out to a depth of 25', emplaced an array of 50 depth-of-disturbance rods for SCUBA diver measurements, deployed three current meters and a pressure transducer in various locations. We also released a half ton of fluorescently tagged sand tracer with SCUBA divers recovering core samples in three different experiments covering different tidal and wave energy regimes. Gateway personnel (R. McIntosh, L. May, J. Tanacredi, J. Rosario, and B. Lane) and divers from FIIS (Northrup, O'Connell, and B. Fulsom) provided essential support to the studies. (see cover)

Preliminary results of the tracer study show that

while most of the sediment moves past the groin during low tide, there is substantial redirection during high tide, so much sand does not move onto the adjacent beach. Although the data are still being analyzed, any conclusions will be limited by the fact that the beach nourishment action between the time of study planning and conduction created a planar profile which is abnormal here. A final one-week study repeating the above procedures but with the addition of five sonar instruments for detecting sediment transport is scheduled for the winter of 1987-88 now that the longshore bar profile has returned. We expect the study then will provide conclusive proof that the Corps' structure is responsible for the beach erosion in the park.

Some of the Gateway study was filmed by WNET-TV for use in a program on science and coastal (mis?) management scheduled for nationwide viewing on public stations this fall and winter. Some aspects of the Fire Island study were presented in an international conference and published: Allen, J.R. and N.P. Psuty, 1987, "Morphodynamics of a single-barred beach with rip channel, Fire Island, NY," *Proc. Coastal Sediments '87*, Am. Soc. Civil Eng., New York, pp. 1964-1975 with reprints available from the senior author. Under the umbrella of the interregional barrier island program based at Rutgers NPS/CRU, we are undertaking two similar studies at Gulf Island NS to better understand the potential effects of a planned massive Navy dredging and disposal project and at Canaveral NS to assess the effects of a revetment constructed adjacent to the northern boundary.

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book review

Mammals in Hawai'i; A Synopsis and Notational Bibliography. Second edition. Bishop Museum special publication 76. Bishop Museum Press, Honolulu. 375 pp. P.Q. Tomich. 1986. \$42.95.

This welcome revision of the standard reference on mammals in Hawai'i comes to us 16 years after the 238-page initial version. The topics remain the same, but with important differences in emphasis. Most notable is the expanded treatment of marine mammals (about 12% vs 5% of the earlier content). The annotated bibliography of 1,500 entries comprises about 43% of the book (vs 36% previously). Species accounts are about the same as in the initial edition (41% vs 43%). The introduction, a checklist, an index, and a section on perspectives in Hawaiian mammalogy, make up the rest of the volume.

The mammals of Hawai'i now include 1 volant (the Hawaiian bat), 2 marine littoral species (the northern elephant seal from Midway Islands has been added), 22 pelagic mammals (whales), and 19 terrestrial species, for a total of 44. The 19 terrestrial species were all brought to Hawai'i by man; the book treats strongly of things Hawaiian which have been lost because of the introductions. The author's introduction deals passionately with Hawaiian environments today and should be read by legislators, teachers, bureaucrats, developers, conservationists, and all who make decisions by default or ignorance. Elsewhere (p. 190), the view of mankind becomes fatalistic: "It is the nature of man to exploit his surroundings for economic or other gain, to ignore wisdom of the past, and to fail to recognize the extreme vulnerability to disturbance that is characteristic of island biotic communities." I would rather hope that the dedication, scholarship, and efforts by individuals such as Tomich will prove Hawai'i an example of how things can be done with future generations in mind.

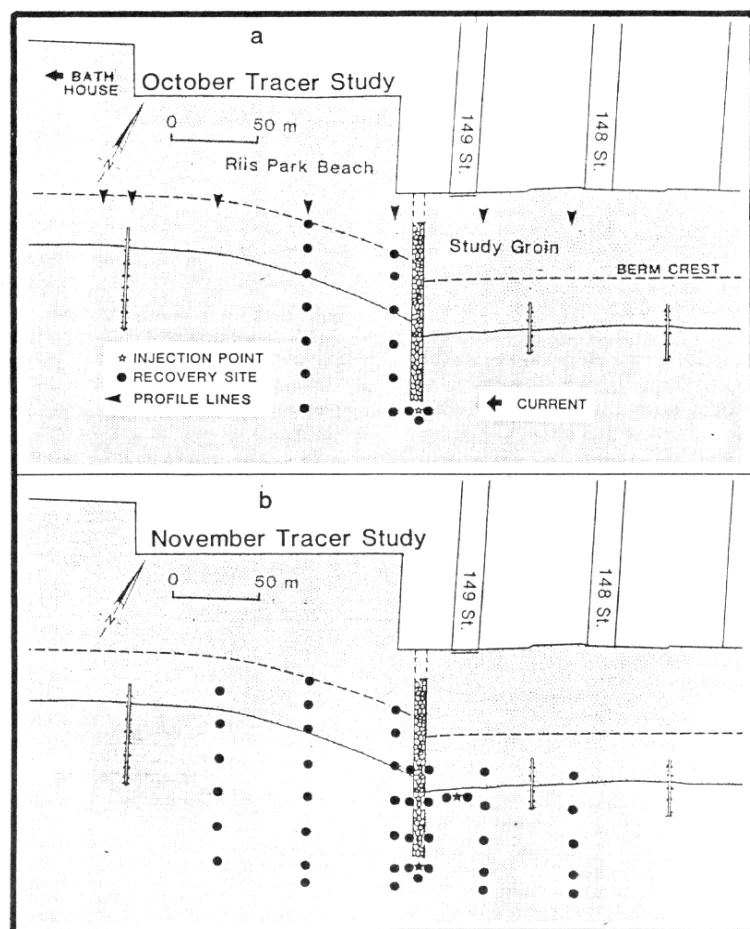
The book contains fair to excellent black and white photographs, a map of the Hawaiian chain, and sketches of whales (with a petroglyph man for scale). I was pleased to see that the author adopted the word "alien" in this edition, rather than "exotic" as in the first edition. It is an appropriately negative term. Further, I wish that the use of Hawaiian names for introduced species (p. 170-171) could be discontinued. Alien species do not belong with things Hawaiian, even words. The detailed treatment of many topics makes it difficult for less interested readers to quickly extract general information. Other sources for this level of knowledge (e.g. van Riper and van Riper 1982), would make a good companion.

Unfortunately, the time involved in the mechanics of publication and the considerable research and management activity in Hawai'i at present, have resulted in some species treatments being less up to date than others. The information on pigs, goats, rats, and mongooses does not reflect important recent research. References to efforts by the U.S. Fish and Wildlife Service, the Nature Conservancy, the National Park Service, and the State of Hawai'i need more emphasis and provide evidence that progress, although slow, is occurring.

Quentin Tomich's book should stand for years as a definitive reference to mammals in Hawai'i and an important source of conservation history for those who wish to learn and to avoid the mistakes of the past.

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Riis Park, Gateway NRA study site showing profiling transects and tracer recovery sites.