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Effects of Hard Stabilization on Dry Beach Width for New Jersey

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ABSTRACT

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Disagreement exists over the role of seawalls and other forms of hard stabilization in degradation of recreational beaches. Potential detrimental effects of sea walls are categorized as placement loss, passive erosion and active erosion. In this study, however, the impact of hard stabilization is studied independently of the question of mechanism of beach degradation. Dry beach widths were measured for the open ocean coast of New Jersey in order to determine the relationship between hard stabilization structures and dry beach width. Beaches were classified as one of five types discriminating on the basis of: (*1*) shore-parallel structure such as seawalls and revetments, (*2*) shore-perpendicular structures such as groins and jetties, (*3*) shore-perpendicular groins with no sand offset on either side, and (*4*) no hard stabilization structures. Beaches with stabilization structures were statistically narrower than the unstructured beaches. Although most of the beaches with shore parallel structures also contained groins, they were classified as a Type I beach and had the narrowest average dry beach width of 9 m. Beaches with groins only (Type II and III) had an average width of 18 m. Unstructured beaches were significantly wider than those with hard structures, averaging 55 m in dry width. Although hard structures may have successfully protected upland property on the New Jersey shoreline, significant beach degradation has resulted from this approach to shoreline management.

ADDITIONAL INDEX WORDS: *Groins, seawalls, engineering structures, beach protection.*

INTRODUCTION

Understanding the interaction of seawalls and beaches is a very important societal problem. This issue was addressed in the recent *Journal of Coastal Research Special Publication No. 4* (KRAUS and PILKEY, 1988). It is a problem that is fraught with controversy as well as with broad economic implications concerning coastal development.

Seawalls and other hard shoreline stabilizing structures are reported to have negative impact on beaches in three ways. These are (1) degradation (narrowing) of the recreational beach, (2) reduction of ease of access to the beach, and (3) reduction of the aesthetic qualities of the beach. On the positive side, seawalls protect upland property, buildings and infrastructure.

The purpose of this study was to investigate the issue of width reduction of recreational beaches caused by hard structures along the New Jersey open shoreline. The impacts of seawalls, groins and other structures on recreational beaches has been the subject of considerable controversy (DEAN, 1985; KRAUS, 1987, 1988; PILKEY and WRIGHT, 1988; TAIT and GRIGGS, 1990; WOOD, 1990). Much of the research to date has involved the study of site-specific, short-term interaction of man-made structures with coastal processes and their impact on beaches. Some of the impacts may be long range, on the order of decades.

The study area, the New Jersey open ocean coast, has the longest history of stabilized barrier island shoreline in North America. Our approach was to measure the dry beach width with intact hard structures and to compare that beach width with adjacent unstabilized beaches. We have observed the endpoint of long term shoreline stabilization. This approach does not address the question of mechanisms of beach and hard stabilization interaction.

Understanding the impact of hard stabilization is important to our society. Coastal man-

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agers in four states (Maine, New Jersey, North Carolina and South Carolina) have already taken steps to prohibit all further hard stabilization of their shorelines. Other states are contemplating such steps.

PILKEY and WRIGHT (1988) and WRIGHT and PILKEY (1989) examined the relationships between dry beach width and the degree of hard stabilization. They made dry beach width measurements every 400 to 500 meters along the entire developed shorelines of New Jersey, North Carolina and South Carolina. The PILKEY and WRIGHT (1989) study compared adjacent stations of stabilized and nonstabilized shorelines. Although they concluded that dry beach width was consistently narrower on coasts with hard stabilization, the results for New Jersey were not as conclusive as those for the Carolinas (PILKEY and WRIGHT, 1988). The wide scatter of the dry beach width data for New Jersey appeared to reflect the widespread presence of sand fillets trapped by groins. Beach width may be affected by both shore parallel and shore perpendicular structures, but these were not differentiated in their study.

The present study improves on the previous Pilkey and Wright studies for New Jersey. It isolates, whenever possible, the effect of shore perpendicular and shore parallel structures on beach width. The Wright and Pilkey studies used simple point measurements; at each station the shoreline was categorized based on the type of hard structure present and the beach width was measured. In this study the total length of each category of shoreline was also measured. The data were then statistically analyzed using both width and length data. It is important to note that this study does not address the mechanics of erosion that may be caused by hard structures, nor is it concerned with the success or failure of hard structures in the protection of beachfront buildings. We are concerned here only with the impact of hard structures on open ocean recreational beaches.

STUDY AREA

The study area, the developed New Jersey open ocean shoreline, is approximately 186 km in length. HALSEY (1979) recognized the following coastal units along the New Jersey coast: northern spit (Sandy Hook), 6 km; northern eroding headlands, 30 km; southern spit, 65 km; southern barrier island chain, 85 km (Figure 1).

The eroding headland section extends from Sea Bright south through Long Branch, Asbury Park and into Bay Head. The headlands (lower than 7 m in elevation) terminate in a low bluff line that borders the narrow beach. The beach sands are coarse-to-medium (modal size 1–1.5ϕ) resulting in steep beach profiles, 7°–12° (MCMASTER, 1954). The southern spit consists of two long islands: Island Beach which extends for 33 km and Long Beach Island, 32 km in length. Beach sands are medium sand size (modal size 1.5–2.0ϕ) and beach profiles are similar to those found in the eroding headland area (MCMASTER, 1954). The barrier island chain, south of Little Egg Inlet, consists of a series of smaller northeast-southwest trending barrier islands. The beaches are characterized by fine-grained sand (modal size 2.5–3.0ϕ) resulting in very low beach profiles, 1°–2° (MCMASTER, 1954). Because of the differences in slope, beaches south of Little Egg Inlet are generally wider than those to the north.

Of the ten inlets along the coast, five (Shark River, Manasquan, Barnegat, Absecon, and Cape May) are stabilized with concreted riprap jetties. Large accumulations of sand occur on the updrift sides of the Barnegat (southside), Absecon (northside), and Cape May (northside) jetties, and only a moderate amount of sand builds up on the southside of the two most northern jetties. On the New Jersey coast fair-weather waves are usually less than 1.5 m high. Their direction, angle of approach, and size vary from place to place and with the season. Historically, the nodal zone for net longshore transport on the New Jersey shore varies between Barnegat and Manasquan Inlets (ASHLEY *et al.*, 1986). The net longshore drift is to the north for areas north of the nodal zone and to the south for areas south of the nodal zone.

The entire New Jersey coastal zone, with the exception of Gateway National Recreation Area on Sandy Hook spit (6 km) and Island Beach State Park (16 km), is highly developed. Location of beach front development varies with each community. Buildings may be found on the beach, protected by a revetment, or on top of or behind dunes. For example, houses in central Avalon are located landward of a forested dune field, whereas houses in the adjacent community of Stone Harbor are built behind a revet-

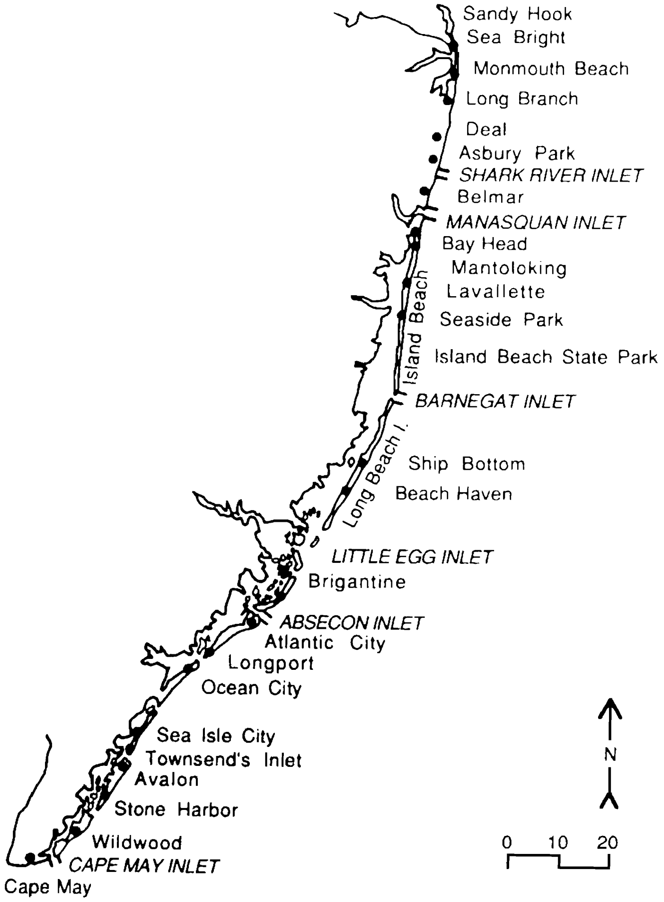

Figure 1. Map of the open ocean coast of New Jersey. The inlets with jetties are shown in larger print.

ment. The type and degree of hard stabilization also varies for each community. For example, most communities on Island Beach, a barrier beach south of Manasquan Inlet, do not have groins while all beaches north of the inlet do. The New Jersey Shore Protection Master Plan (NJDEP, 1981) provides a complete description of shoreline stabilization structures for each community.

THE PROBLEM

In the 1990, Natural Academy of Engineering report entitled Managing Coastal Erosion (WOOD, 1990) stated: "Properly engineered seawalls and revetments can protect the land behind them without causing adverse effects to the fronting beaches." TAIT and GRIGGS (1990) argue that if a shoreline is retreating, as almost all barrier island shorelines are, seawalls will cause loss of recreational beaches by simply establishing a fixed line in the sand against which the beach narrows. Many researchers have discussed the potential detrimental effects caused by the placement of shoreline stabilizing hard structures on beaches and have categorized beach degradation mechanisms as (1) placement loss, (2) passive erosion, and (3) active erosion.

Placement loss occurs when a seawall is placed below the high tide line on the beach. Thus, on the day of completion of a seawall, the usable recreational beach has been narrowed. Prevention of exchange of sand between dunes and beaches and removing sand supply by taking eroding bluffs out of the sand supply system is also part of placement loss (McCormick *et al.*, 1984; Oertel, 1974). Placement loss of the beach occurred in Miami Beach, Florida, in the 1960s and 1970s (Kaufman and Pilkey, 1983) and in Sandbridge, Virginia, in 1989.

Passive erosion occurs when the dune line is armored or replaced by a fixed engineered structure, thereby holding the landward boundary of the beach stationary (Wright and Pilkey, 1989). As erosion or shoreline retreat continues, the high water line moves inland towards the structure and the beach is narrowed. Eventually the structure will "project into the surf zone" (Dean, 1985), and there will be no dry beach. There is opposition to the validity of the concept of passive erosion in front of walls (Basco, 1989), but many agree that passive erosion is a major factor in long term degradation of beaches. Long-term data showing this are reported from Denmark (Mikkelsen, 1987) and Australia (MacDonald and Patterson, 1984). Tait and Griggs (1990), in their summary paper concerned with beach responses to seawalls note:

"The most important factor affecting the potential impact of a seawall on the beach is whether there is long term shoreline retreat. Where long-term retreat is taking place, as is the case with many of the Atlantic and Gulf coast barrier islands, and the process cannot be mitigated, then the beaches in front of seawalls in these locations will eventually disappear."

Active erosion describes any process that accelerates beach erosion due to the presence of stabilizing structures. Active erosion involves redistribution of sediment supply and/or modification of shore zone processes (Pilkey and Wright, 1988). The detrimental effects due to placement loss and passive erosion are well documented, but degradation due to active erosion is more controversial. Active erosion by hard structures may involve one of the following:

(1) Erosion of adjacent beaches as sand moves in and is deposited to maintain the profile in front of seawalls, bulkheads, and revetments (Walton and Sensabaugh, 1979; Dean and Maurmeyer, 1983; and Kraus, 1988). Sand is most likely derived from adjacent beaches, thereby causing more erosion in those locations than if no seawall were present.

(2) Shoreface steepening which may be a long-term change and is presently not well documented (Pilkey and Wright, 1988). Morton (1988) notes that the presence of seawalls on the Texas coast impedes the total recovery of the beach after storm erosion. He finds that with time, the profiles steepen. However, Kraus *et al.* (1988) conclude that beach profiles in a seawalled section did not change.

Kraus (1987, 1988), who has reviewed over 100 articles on effects of seawalls on beaches, concludes that beaches with and without seawalls exhibit similar behavior during short term events such as storms. Further, seawalls appear to be "relatively innocuous with regard to cross shore sediment processes," and are only potentially damaging to adjacent beaches when longshore processes are interrupted. He indicates that beach erosion adjacent to seawalls is similar to that on beaches without seawalls, if an adequate sediment supply exists. One of the difficulties with short term and event studies of seawall impacts is that beach degradation is often a long term (several decades) phenomenon. Clearly, from his reviews, much remains to be resolved about any active erosional impacts of seawalls.

Probably the most important paper opposing the concept of active participation of seawalls in beach erosion is Dean (1985), who contends that passive erosion does occur in walled areas, but that active erosion caused by walls is insignificant. According to Dean (1985), coastal armoring does not accelerate beach erosion except in areas downdrift of groins (groin effect). He also indicates that coastal armoring placed on an eroding shoreline causes increased erosion on adjacent beaches and will cause erosion on the seaward beach (passive erosion). As to the concept of accelerated erosion and delayed post storm recovery, Dean (1985) holds that "no known data or physical arguments support this concern."

Groins, the most common method of hard stabilization, have long been recognized as successful in retaining or increasing beach width on the updrift side, while causing active erosion and narrowing of the beach downdrift (Duane, 1976).

Hard Stabilization in New Jersey

The State of New Jersey has allowed the use of hard stabilization for protection of structures and infrastructures for over 100 years. The first stabilization at Seabright and Sandy Hook occurred around 1870 (PILKEY and WRIGHT, 1988). COOK (1885) noted the presence of a stone seawall at Cape May and bulkheads at Long Branch with others under construction in Elberon. SMOCK (1893), after a trip to Holland, proposed that the coastal bluff at Long Branch be terraced and faced with stone.

During this century, over 300 groins, along with extensive revetments, bulkheads, and seawalls, have been constructed as a means of holding beach sand in place and protecting upland buildings. By the early 1980s, the state adopted the New Jersey Shore Protection Master Plan (NJDEP, 1981) which initiated stricter regulations for the building of any new hard stabilization structures and established preference for nonstructural methods, such as beach replenishment and dune building (NJDEP, 1986).

At present, hard stabilization structures along the New Jersey coast fall into two categories: (1) shore-parallel structures such as seawalls, revetments and bulkheads; and (2) shore-perpendicular structures, such as groins and jetties. Seawalls are solid structures, intended to resist the full force of waves as seen at Cape May, Sea Bright, Monmouth Beach, Long Branch, Deal, and Longport. Revetments are a facing of stone (riprap), built to protect a scarp or embankment against wave action or currents, as found in Bay Head, Ventnor, Stone Harbor and sections of Sea Isle City. Bulkheads, designed to retain or prevent sliding of the upland and protect from wave attack, are found in Lavallette, Brigantine, Atlantic and Ocean Cities. In Seaside Park, Bradley Beach, Belmar, Asbury Park, and Atlantic City bulkheads are under or on the landward side of boardwalks. Groins, placed perpendicular to the shore, are designed to trap a portion of the longshore drift to widen a particular beach. These have been constructed in many communities on the New Jersey shore.

METHODS

Dry beach width is defined as the distance between the high water line and the active dune line or the toe of a stabilizing structure. In unstabilized zones where there were no dunes, the vegetation line was used as the back boundary for the beach. WRIGHT and PILKEY (1989) suggest using the dry beach width as a measure of recreational beach "quality" because it has several clear advantages. It is easy to measure regardless of the tidal stage and, more importantly, it represents the width of the beach usable for recreation at high tide. A major disadvantage is the temporal variability in the measurement of dry beach. Storms and spring tides may temporarily reduce the dry beach width. Measurements in this study were taken at a time when neither spring tides nor storm waves had an obvious impact on the dry beach width.

During May and June 1989, the dry beach width was measured at 770 sites along the New Jersey open coast. Sites for measurement were chosen wherever the dry beach width increased or decreased and/or the type of hard structure changed. At each site the beach width was measured and the type(s) of stabilization noted. In order to show the total beach length affected by each hard structure, the distance was between sites was determined with a measuring tape. A wider beach on the updrift side of a groin was measured for its width and length. The narrower beach on the downdrift side was taken as another station where width and length were measured in order to observe the groin effect. If there was a stretch of beach between groins with uniform width apparently not affected by groins, it was measured separately for width and length and recorded as a "nonstructured" beach section. By this means, the effect of groins was separated from unaffected areas.

Field studies were augmented by study of June, 1986 aerial photographs for the entire length of the coast taken by the New Jersey Division of Coastal Resources. These photographs were used to verify location and length of hard structures and the lengths of stabilized and unstabilized shorelines.

RESULTS AND DISCUSSION

The beaches were divided into five categories based on the degree and type of stabilization.

Type I beaches are those with shore parallel structures (seawalls, revetments, and bulkheads) which are currently exposed and in front of any dunes (Figure 2). Although this type was intended to include only beaches with shore parallel structures, we found that most of beaches with seawalls, revetments and bulkheads also have groins. Only five beach segments (Seaside Park, mid-Atlantic City, Ventnor, Margate, and South Ocean City) were backed with shore parallel structures and no groins. The middle three have also been recently replenished. Thus Type I beaches although still treated as those backed by seawalls, must be noted that groins are present in most cases. Type II beaches are those with shore perpendicular structures only (groins and jetties) and show accumulation on the updrift and/or erosion on the downdrift side (Figure 3). Beaches with groins and no apparent sediment offset are classified as Type III (Figure 4). Type IV beaches are those with no visible hard structures (Figure 5). Recently replenished beaches are classified as Type V, regardless of whether they have hard structures or not.

In New Jersey, 49% of the total length of all the developed open ocean beaches were found to be unprotected (IV), 21.3% have groins or jetties (II), 17.3% have seawalls (I), 10.3% are groined with no offset (III), and the remaining 4% have recently been replenished (V).

Table 1 lists the beach width data for each type of shoreline. Replenished beaches that still retain their fill were excluded in the data analysis because their beach widths would not be a true reflection of natural conditions. The right hand column lists the percent of each width for each beach type.

Figure 6 shows a comparison of the beach width of structured (black) versus unstructured (stippled) beaches. Two things are apparent: the unstructured or natural beaches are usu-

Figure 2. A Type I beach with a shore parallel structure, a seawall as seen here in Sea Bright.

Figure 3. Type II beach with shore parallel structures and a variable beach width due the sand offset by the groins in Ocean City.

ally wider than nearby structured beaches, and the beaches north of Little Egg Inlet are generally narrower than those to the south. The occasional wide beaches in the northern section are due to the sand accumulation on the updrift sides of the jetties at Barnegat, Manasquan, and Shark River Inlets. The widest beach section (212 to 454 m) of the coast is found on the Wildwood barrier island. The wide stretch (212–220 m) on the southern end of Wildwood Crest is due to the effect of the Cape May Inlet jetty. The wide beach in Wildwood and North Wildwood (unstructured) may be related to changes that occurred during dredging of the inlet channel to the north (Sue Halsey, *pers. comm.*, N.J. Division of Coastal Resources).

Table 2 summarizes the data from the beach width measurements (weighted for length of beach). The seawalled beaches (Type I), have the narrowest mean dry beach width (9 m). Half of the total length of beaches with walls (15.5 km) have no dry beach at all. Beaches with groins and jetties (Type II and III), regardless of whether there was sediment offset or not, are not significantly different. They have mean dry beach widths of 18 and 19 m respectively. The unstructured beaches (Type IV), have a mean width of 55 m. In this group several beaches have widths in excess of 150 m. Approximately 15 percent of unstructured beaches are of greater width than the maximum width of any other group (Figure 7).

The Mann-Whitney U-test, a method that searches for central tendency differences between two populations (*e.g.*, seawalled versus nonstructured beach widths or groined versus nonstructured beaches), was used to statistically analyze the beach width data. The null hypothesis is that two data sets of beach width are not significantly different. The calculated Z

Figure 4. Type III beach, shore perpendicular structure with no offset, as seen in Stone Harbor.

values (Table 3) indicate that this hypothesis is rejected at the 0.05 level. Unstructured beaches have significantly wider beaches than each of the structured type of beaches.

Adjacent beaches are most likely to be affected by similar wave and storm conditions. A comparison of adjacent structured to unstructured beaches is useful in examining the relationship between stabilization and beach width. To illustrate this point, several examples along the New Jersey coastline are discussed below.

Stone Harbor has a partially sand covered bulkhead and a series of groins with moderate offset of approximately 6 m and dry beach widths varying from 28 to 38 m. Immediately to the north is Avalon (area south of 30th Street) with no hard structures and a large dune field that is heavily vegetated; dry beach widths average 76 m. There is a small groin field on the north end of Avalon (north of 30th Street) and dry beach widths decrease to less than 30 m.

There is only a bulkhead along the beach on the south end of Ocean City where dry beach width is 32 m. Proceeding northward from that point in Ocean City, the beach becomes heavily groined and backed by bulkheads. At this point, beaches are less than 10 m wide on the updrift side and, there is no beach on the downdrift side.

The impact of hard stabilization is seen quite clearly in Brigantine. The southern portion of the island has a well established dune field, no structures, and the beaches are wide (70–90 m). In the southern most section, beaches are even wider (124 m) because of sand accumulation updrift of the jetty at Absecon Inlet. In the central section, where groins (Type III, no offset) and a bulkhead exist, the dry beach width narrows (7–27 m). Farther north, beyond hard stabilization, dry beach width again increases (70–90 m).

Sections of Long Beach Island are heavily

Figure 5. Type IV beach, one with no hard stabilization structures. Note the relatively uniform beach width for the Bay Head area.

Table 1. *The width and corresponding length for each beach type (in meters).*

	I Walls		II Groins		III Groins (no offset)		IV Unstructured	
Beach Width	Beach Length	%	Beach Length	%	Beach Length	%	Beach Length	%
0	15,467	51	3,194	8.5	0	0	0	0
1–10	6,622	21.7	20,274	35	2,000	13.1	8,637	10.4
11–20	3,364	11	7,787	20.8	9,757	64.3	10,022	12.1
21–30	1,667	5.5	6,878	18.4	2,258	14.8	32,727	39.6
31–40	1,636	5.4	1,712	4.6	1,212	7.9	1,061	
41–50	151	0.5	3,697	9.9	0	0	4,454	5.4
51–60	0	0	1,000	2.7	0	0	2,303	2.7
61–70	1,424	4.7	0	0	0	0	13,030	15.7
> 71	0	0	0	0	0	0	10,394	12.5

groined and many groins have no dry beach on the downdrift side. Beaches, where they exist, are narrow (7–12 m). In the center of this island is the community of Ship Bottom where there are no groins and the beaches are wider (18–24 m).

The undeveloped Island Beach State Park has a beach 30 m in width. North of the park the

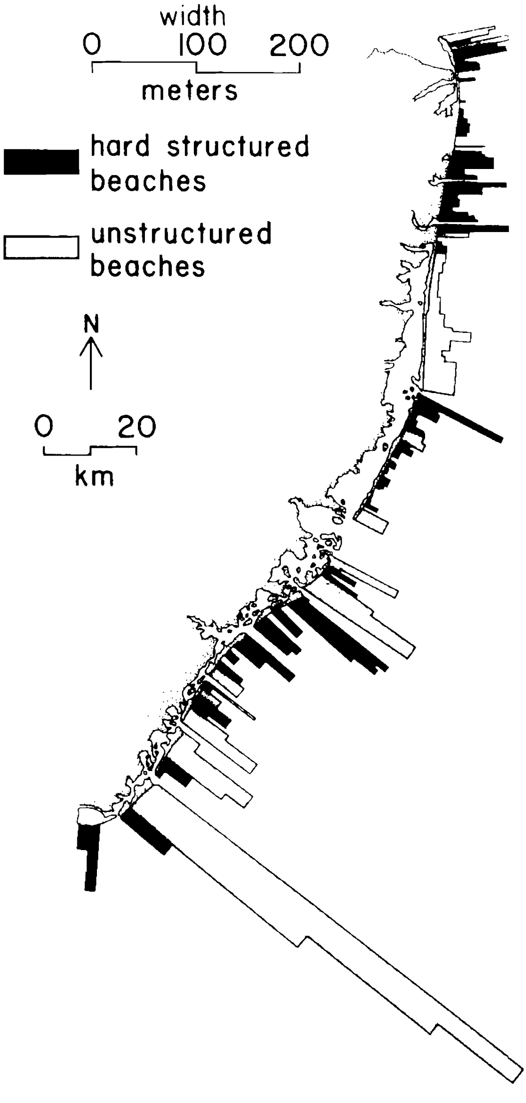

Figure 6. Beach width for beaches stabilized with hard structures (black) versus beaches with no hard structures (stippled). The wide "spikes" in black reflect the presence of jetties at Cape May, Barnegat, Manasquan, and Shark River Inlets. Also apparent is difference in width of beaches north and south of Little Egg Inlet. In general, those to the south are wider than those to the north.

beach narrows to 18–24 m in developed but unstructured areas. In this stretch of coast, beach width appears to vary with the placement of houses relative to the dunes. Where houses were built on the crest of dunes (Normandy Beach, Mantoloking, and Bay Head), the beach width was 11 to 13 m. To the north, Point Pleasant, and to the south, Seaside Heights and Seaside Park, where houses sit behind the dunes, the beach width is more than twice as wide (24–30 m).

As the density of hard structures increases north of Manasquan Inlet the beach width narrows. Groins are 100 to 150 m apart in Sea Girt

Table 2. *Beach width (in m) for beach types I-IV. Means are based on the total length for each beach section.*

Type	Minimum Width	Maximum Width	Median Width	Mean Width
I SEAWALLS	0	65.5	0	9
II GROINS	0	60.6	12	18
III GROINS	7	39	18	19
IV UNSTRUCTURED	6	454	38	55

and Spring Lake, and dunes are minimal or absent. Beaches are relatively narrow, 10–12 m. Farther north, in Elberon and Long Branch, groins are 70 m apart and revetments are present. The dry beach width is less than 9 m, and in many places there is no beach. North of this area is Monmouth Beach and Sea Bright which are seawalled and groined. Most of this area has no dry beach (Figure 2).

In order to examine the steeper northern beaches and the flatter southern beaches separately, general statistics were computed for the two different stretches of shoreline north and south of Little Egg Inlet (Table 4). Although the mean widths for each beach type are different north and south of Little Egg Inlet, overall, structured beaches are narrower than the unstructured beaches.

CONCLUSIONS

We have completed a snapshot observation of the New Jersey coast in seeking to understand the impact of hard structures on beach quality. This snapshot view is a useful approach because of the difficulties of studying and evaluating a process (beach versus hard structure interaction) that may take years to complete. If the study were repeated tomorrow, different numbers would probably be obtained because of the variability of dry beach width, seasonally and after storm events. If the study were carried out after another 1962 Ash Wednesday storm the study would be meaningless as no dry beach width would exist anywhere. As stated earlier, variations in dry beach width on structured beaches could be a function of placement loss, passive erosion and/or possible active erosion processes. We did not and could not address the mechanism of beach loss in this type of study. We have only observed the end point.

There are a number of indicators that our study has provided useful results. For example, where WRIGHT and PILKEY (1988) data for the same area are similar, dry beach widths are about the same. In addition, dry beach widths

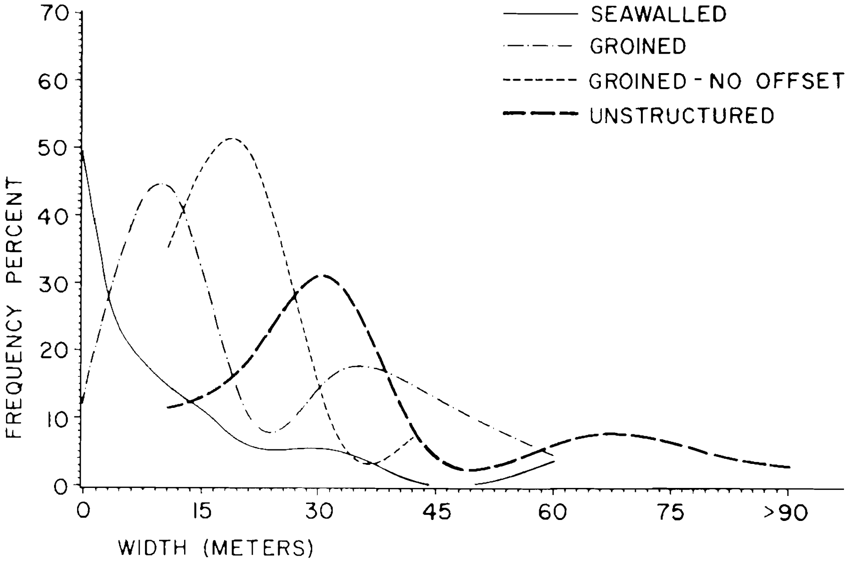

Figure 7. Frequency of beach width for the four types of beaches.

Table 3. *Comparison (Mann-Whitney U test) of beach widths for structured and unstructured beaches.*

	Seawalls	Groins	Groins (n.o)	Unstructured
Seawalls	—	0.72	0.40	2.79
Groins		—	0.91	1.78
Groins (no offset)			—	2.57
Unstructured				—

Z-values in the table are calculated by the formula:

$$Z = \frac{2T - n_1 (n_1 + n_2 + 1)}{(n_1 n_2 (n_1 + n_2 + 1)/3)} \; 1/2$$

where: T is the sum of ranks of the smaller sample, n_1 is the number of beaches in the larger sample, and n_2 is the number of beaches in the smaller sample. At Z values > 1.645, the H_o is rejected, concluding that there is a significant difference in beaches with structures and beaches without structures.

observed in the 1986 aerial photos are generally similar to those measured in the field of the summer of 1989.

We have chosen New Jersey for this study because it has a longer history of hard shoreline stabilization than any other state. Dry beach width is used as a measure of beach quality because it is very easy to measure. A better measure of beach condition might be beach width between high and low tide lines or beach profiles corrected for seasonal changes. Perhaps the next logical phase of the study of beach/seawall interaction would be profiling. However, the next phase would involve an order of magnitude leap in time and cost of the study.

For the open ocean coast of New Jersey, the dry beach width is narrower on beaches stabilized by hard structures compared to unstructured beaches. The width of dry beach also appears to be a function of the density of hard stabilization: the greater the density of stabilizing structures, the narrower the beach. Dry beaches with seawalls, bulkheads, and revetments are the narrowest. Groins are also present on most of these seawalled beaches. Due to simultaneous occurrences of both types of structures, we were not able to separate the effects of shore parallel from shore perpendicular structures, it is interesting to note that approximately 51% of areas that are seawalled have no beach, except in a few cases where groins have trapped sand on the updrift side. This phenomenon is particularly evident along Cape May and Sea Bright, New Jersey (Figure 8).

Table 4. *Widths (in m) for beaches north and south of Little Egg Inlet. For northern beaches, the slope is 7–12° and average grain size is 1.0–1.5°. For southern beaches, the slope is 1–2° and average grain size 2.5–3.0°.*

Type	Minimum Width	Maximum Width	Median Width	Mean Width
Beaches North of Little Egg Inlet				
I Seawalls	0	21	0	5
II Groins	0	38	9	11
III Groins (no offset)	8	30	18	17
IV Unstructured	6	91	30	24
Beaches South of Little Egg Inlet				
I Seawalls	0	64	4	14.5
II Groins	0	61	18	20
III Groins (no offset)	18	45	21	27
IV Unstructured	18	454	54.5	86

We conclude that walls are more responsible for the lack of beach than groins. Beaches with only groins and jetties are slightly less narrow than seawalled beaches. The exceptions are the beaches on the updrift side of jetties, at Cape May, Absecon, Barnegat, Manasquan, and Shark River Inlets. The impact of all structures on the dry beach width varies from site to site.

On the whole, unstabilized dry beaches are wider than adjacent stabilized dry beaches. Unstabilized dry beaches are relatively narrow in a few areas, but these are areas of recent erosion and escarpment of the steeper beaches (*i.e.* Mantoloking and Normandy Beach).

The New Jersey shoreline, in many places stabilized for longer than a century, provides evidence of the degradational effect of hard stabilization on recreational beaches. The impact is apparent whether structures involved are shore parallel or shore perpendicular. On the other hand, there are a number of areas where no beach would exist at all if it were not for sand retention behind groins or jetties.

The New Jersey experience clearly indicates that, if preservation of recreational beach is a major societal goal in coastal management, hard structures should be avoided, if at all possible. In a time of rising sea level and expected acceleration of this rise, hard stabilization is a "tempting" solution to the erosion problem, especially if preservation of shorefront buildings is a high, societal priority. Hard structures may seem to be the answer, but it must be realized that they are preserving property at the long term cost of the quality of the beach.

Figure 8. A seawalled section of the coast where the dry beach exists only on the updrift side of groins. Most of the New Jersey coast that has shore parallel structures also has a groin field as seen in this photograph of Sea Bright.

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RÉSUMÉ

Il y a désaccord sur le facteur de dégradation des plages récréatives par les digues et autres formes de construction en dur pour la stabilisation. L'effet potentiel de dégraduatiuon est divisé en 3 catégories: perte sur plaéce, érosion passive, érosion active. L'étude des stabilisations en dur ne tient pas compte de la question des mécanismes de dégradation de la plage. La largeur de la plage sèche a été mesurée sur les côtes océaniques ouvertes du New Jersey, en vue de déterminer la relation entre les structures en sur et la largeur de la plage sèche. Les plages ont été classées en 5 types selon qu'elles sont équipées (1) de structures paralléles à la plage, comme les digues ou les revêtements, (2) de structures perpendiculaires: jetées ou épis; (3) d'épis perpendiculaires à la plage sans compensation sableuse de chaque côté; (4) sans structure en dur. Statistiquement, les plages avec structure de stabilisation sont plus étroites que les plages sans structure. La plupart des plages à structures parallèles comprenaient aussi des épis ont été classées dans le type 1 et sont les moins larges (9 m). Les plages à épis seuls (Types 2 et 3) ont en moyenne 18 m de large. Les plages sans structure sont significativement pllus larges (55 m en moyenne) que celles avec des protections en dur. Bien que la plupart de ces structures ainet pu protéger avèc succés les propriétés de l'avant plage des côtes du New Jersey, il en a résulté une dégradation significative de la plage.—*Catherine Bousquet-Bressolier, Géomorphologie EPHE, Montrouge, France.*

ZUSAMMENFASSUNG

Es existiert keine Überinstimmung über die Rolle, die Strandmauern, Deiche, Dämme und andere Formen einer "festen" Stabilisierung erosionsgefährdeter Strände, die unter Freizeitnutzung stehen, spielen. Potentielle schädliche Auswirkungen von Strandmauern werden eingeteilt in Verluste bei der Errichtung, durch passive Erosion und durch aktive Erosion. In dieser Studie wird der Einfluβ der o.g. Küstenbefestigungen unabhängig von der Frage nach dem Mechanismus der Stranddegradation untersucht. Die Breite trockener Strände wurde an der Atlantikküste New Jerseay gemessen um die Beziehung zwischen Strandmauern und der Strandbreite zu ermitteln. Die Strände wurden in fünf Gruppen eingeteilt, die auf der Basis von (I) küstenparallelen Bauten wie z.B. Deiche und Ufermauern, von (II) Bauten die senkrecht zur Küste angebracht wurden wie z.B. Buhnen und Molen, von (III) senkrecht zur Küste stehenden Buhnen ohne Sandauflagerung an der Seite und von (IV) sog. "weichen" Küstenbefestigungen ausgegliedert wurden. Strände ohne Befestigungsstrukturen waren statistisch schmaler als solche ohne Befestigungen. Obwohl die meisten Strände mit küstenparallelen Befestigungen auch Buhnen besaβen, wurden sie der Gruppe I zugeordnet. Sie hatten den durchschnittlich schmalsten Trockenstrand mit einer Breite von 9 Metern. Strände, die nur mit Buhnen versehen waren (Typen II und III), hatten eine durchschnittliche Breite von 18 Metern. Unbefestigte Strände waren signifikant breiter als solche mit Befestigungsbauwerken und erreichten eineü durchschnittliche Breite von 55 Metern trockener Strand. Obwohl Befestigungsanlagen wahrscheinlich erfolgreich den höhergelegenen Besitz an der Küstenlinie New Jerseys geschützt haben, hat bedingt durch die bisher durchgeführten Maßnahmen des Strandschutzes eine signifikanten Stranddegradation stattgefunden.—*Ulrich Radtke, Geographisches Institut, Universität Düsseldorf, F.R.G.*

☐ RESUMEN ☐

Existe desacuerdo sobre el papel de los diques y otras formas duras de estabilización en cuanto a la degradación de playas de recreo. Los efectos nocivos de los diques se clasifican en pérdida de espacio, erosión pasiva y erosión activa. En este estudio, sin embargo, el impacto de la estabilización rígida se estudia independientemente del mecanismo de degradación de la playa. Se midió el ancho de playa seca de la costa de New Jersey para determinar la relación entre el tipo de estabilización rígida y el ancho de playa seca. Las playas se clasificaron en 4 tipos, con base en el tipo de estabilización: (1) Estructuras paralelas a la costa, tanto diques como muros de contención, (2) estructuras perpendiculares a la costa, tanto diques como pantalanes, (3) diques perpendiculares sin trasvase de arena y (4) son estructuras de estabilización. Las playas con estructuras de estabilización son estadísticamente más estrechas que las playas sin estructuras. Aunque la mayoría de las playas con estructuras paralelas a la costa tiene también diques perpendiculares, éstas se clasificaron en el tipo 1 y tienen el menor ancho medio de playa seca con 9 m. La playa con dique perpendicular solamente (tipos 2 y 3) tiene un ancho medio de 18 m. Las playas sin estructura son significativamente más anchas que aquéllas con estructuras rígidas, siendo su ancho medio de 55 cm. Aunque las estructuras rígidas pueden haber protegido adecuadamente las tierras altas de la costa de New Jersey, al final ha resultado que ha habido una degradación significativa de la costa.—*Department of Water Sciences, University of Cantabria, Santander, Spain.*