On the Continued Cost of Upkeep Related to Groins and Jetties

Author: Pietrafesa, L.J

Source: Journal of Coastal Research, 28(5)

Published By: Coastal Education and Research Foundation

URL: https://doi.org/10.2112/JCOASTRES-D-12A-00004.1

Journal of Coastal Research	28	5	iii–ix	Coconut Creek, Florida	September 2012

LETTERS TO THE EDITOR

Letters to the Editor in the *Journal of Coastal Research* are opinion pieces written by coastal researchers or laypersons that usually deal with topics that are important to the research community. Although these contributions state opinions or give perspectives on topical issues of concern, they must be based on facts and evidence. Even though Letters to the Editor may contain personal bias, the commentary should reflect a stance, concern, warning, or opinion with some basis in fact regardless of how it is interpreted. Letters to the Editor are an independent part of the JCR where opinions and positionalities are not vetted in peer review as are professional papers and technical communications. Letters to the Editor are opinion pieces that reflect authors' positions and are not necessarily a part of the journal's position on any topic.

On the Continued Cost of Upkeep Related to Groins and Jetties

L.J. Pietrafesa

Coastal Carolina University
Center for Marine & Wetland Studies
P.O. Box 261954
Conway, SC 29528, U.S.A.
len_pietrafesa@ncsu.edu

ABSTRACT

Pietrafesa, L.J., 2012. On the continued cost of upkeep related to groins and jetties. *Journal of Coastal Research,* 28(5), iii–ix. Coconut Creek (Florida), ISSN 0749-0208.

So-called terminal groins, which are actually jetties at the terminus of barrier islands where inlets are located, have been the subject of controversy for half a century in North Carolina. Coastal scientists have opposed these hardened structures and point to their destructive effects upon downstream beaches, requiring ever increasing and costly beach renourishment projects. Meanwhile, some coastal engineers have claimed that they can be used to "stabilize" migrating inlets. Local politicians, in response to real estate interests, have argued for the construction of the hardened structures and, in contrast to the claims of the scientists on the ground, have cited examples of success in North Carolina and at other locales on the U.S. eastern seaboard. So what are the facts? This Editorial presents the documented facts for North Carolina and the other U.S. east coast locales.

ADDITIONAL INDEX WORDS: *Groins, jetties, barrier islands, beaches, erosion, deposition, renourishment, inlets, storms, sea level rise, tides, waves, downstream*.

INTRODUCTION

In 2003 the North Carolina Legislature voted, yet again, unanimously to ban the construction of new, permanent erosion-control structures from NC's ocean shorelines (including inlets), Session Law 2003–427. There were no dissenting votes in either chamber. This unanimity resulted from the recognition that the North Carolina Coastal Resources Committees had imposed a ban on coastal hard structures, which was enacted in 1985. It was viewed as sound fiscal, environmental, and management policy; however, a new North Carolina Legislature reconsidered the issue and in 2011 voted in favor of Bill S832, which would permit the construction of "terminal groins" along the North Carolina coast.

In the December 2011 issue of *News Breakers*, Ocean Isle Beach (OIB), North Carolina, Mayor Debbie Smith (Smith, 2011, p. 3) states:

Ocean Isle Beach has had a very successful beach nourishment project covering three miles of our beach since 2001. However, beach nourishment adjacent to an inlet is difficult to be maintained because of the constant shifting nature of the adjacent Shallotte Inlet; at the mouth of the Shallotte River. Recently the NC Legislature passed legislation giving coastal towns and counties a tool to utilize the stabilization of beaches adjacent to inlets. Senate Bill 110 allows pilot projects of up to four terminal groins to be constructed in North Carolina. These structures have been used successfully in many coastal states for years. In fact there are two existing terminal groins built by the State of NC that have protected historic Fort Macon on the north end of Atlantic Beach and another terminal groin that has secured the end of Bonner Bridge over Oregon Inlet.

Mayor Smith then makes a leap and claims that a terminal groin (or in classic definitions a "jetty") will stabilize Shallotte Inlet, North Carolina, at the east end of OIB, thus, in her train of logic, eradicating beach erosion. She then reaches the conclusion that the terminal groin/jetty will eliminate the continual need for costly beach renourishment projects. In the words of Mayor Smith:

DOI: 10.2112/JCOASTRES-D-12A-00004.1; received and accepted in revision 23 February 2012.

With a terminal groin in place we may reduce the renourishment cycles which will certainly be a substantial cost savings for our beach management program. Other viable benefits from construction of a terminal groin are elimination of unsightly sand bag installations, improvement of the natural habitat for birds and turtles and better protection of our roads, utilities and properties.

Mayor Smith is not alone in her belief in the positive value of hardening the fragile beaches of North Carolina. In the January 12, 2012, issue of the *Brunswick Beacon* (Lewis, 2012), Mayor Alan Holden is calling for a groin/jetty to be built at the east end of Holden Beach, which is east of OIB. There are also potential applications for hardened structures at Figure Eight Island, North Carolina; Bald Head Island, North Carolina; North Topsail Beach, North Carolina; and Shackleford Banks, North Carolina.

It is of note here that the classic definition of a jetty is the emplacement of a solid structure, generally perpendicular to the coastline, and more often than not at the terminus of an island. The word jetty has taken on negative connotations from the coastal sciences community because they have come to be associated with many examples of structures that have created more damage, which required costlier solutions that never worked permanently. Thus, the reference in the Mayor's write-up to "renourishment cycles" is explained. Alternatively, the term "terminal groin" has been classically known as the last or terminal groin in a field of groins and is thus far more palatable to the uninformed ear than the alternative jetty. But the point here is not to debate definitions; rather, it is to present the facts and thus expose the misrepresentations.

In her article Mayor Smith then provides aerial photos. One was taken in 1993 of Fort Macon, North Carolina, at the eastern end of Atlantic Beach, North Carolina, with no beach obvious, east of the Fort Macon groin. The second aerial photo, taken in 2007, shows copious amounts of sand in place to the east of the groin, leading to the obvious conclusion that the groin/jetty was responsible for the sand accretion. This all sounds and looks good, but unfortunately the claims made by the Mayor are misleading, misrepresentative, incomplete, and thus dangerously incorrect. So, just what are the facts of the matter for Fort Macon/Atlantic Beach, North Carolina, and for other locales along the eastern seaboard of the United States where groins/jetties have been placed at a tidal inlet or river mouth?

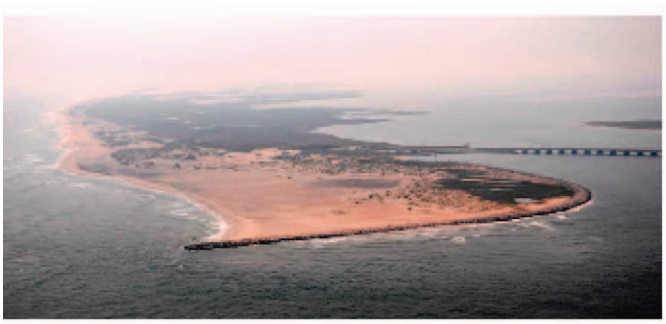
THE FACTS

From the early 19th century and well into the 20th century there was a series of failed engineering projects, all designed ostensibly to stabilize the inlet at the eastern end of Atlantic Beach, North Carolina, just beyond Fort Macon. The many prior projects had attempted to stabilize, *i.e.,* stop, the migrating island end and thus, presumably, prevent the naturally occurring erosion of beach sediments at that locale. In 1960 a major, presumably more comprehensive, construction project was initiated and was completed in 1970, with the final stage of emplacement of a rock groin/jetty. Therefore, the groin that Mayor Smith alludes to in the 1993 photograph actually had been in place, in its entirety, in 1970.

It is of considerable note here that along the eastern seaboard of the United States, from Maine to the Florida Keys, coastal sediments move on average from north to south and east to west. These sediments emanate from coastal rivers and embayments and from marine sediments resuspended during the passage of severe storms along the adjacent continental shelf. During the passages of atmospheric storms these sediments are carried in the directions of the ocean currents and waves, which along the eastern seaboard of the United States are directed predominantly from north to south and east to west as the storms move predominantly from south to north. This is because winter storms, also called "nor-easters," and hurricanes move from SW to NE, and the winds on the coastal sides of the storms blow toward the SW quadrant. As a consequence, barrier islands actually move or "migrate" from north to south and east to west on average during the passages of these storms, which are highly persistent and energetic. Further the islands also move toward the mainland on the back or sound sides of the islands. These naturally occurring processes are well known to the coastal science community. It is also well known that when hardened structures are put in place in an effort to subvert or prevent the naturally occurring processes, they result in serious damage to the beaches and moreover could actually destroy the barrier islands. To counteract these destructive effects, massive expenditures of investments to accelerate the "beach renourishment" projects have been required. The facts speak for themselves. Let us revisit Atlantic Beach/Fort Macon.

The completed construction of the Atlantic Beach/Fort Macon Groin/Jetty in 1970 was supposed to result in the salvation of the beach, which had a long documented history of being eroded, and the build-up and build-out of the east end of Atlantic Beach. In 1961, during the initial stages of groin/jetty construction, a $6.78 million (in 2009 dollars, which will be the case for all figures quoted) beach-renourishment project was also conducted, and the beach was restored. Yet in 1973, just 12 years after the prior 1961 major beach-renourishment project and only 3 years after the groin was completed, a new beach-renourishment project had to be staged. Why? The answer was to deal with the exacerbated erosion that had occurred during and following groin/jetty construction-completion because of, not in lieu of, the groin/jetty. The cost of the project was $1.99 million. So, did the new groin coupled with the $8.77 million spent in beach renourishment solve the problem at Fort Macon, North Carolina? The answer is no, as presented in further discussion.

From 1973 to 2007 there has been an additional seven renourishment projects that have been staged at Fort Macon, North Carolina, for a total expenditure of $44,894,830 in public dollars. The beach-renourishment project that occurred in 2007 is the reason that the aerial photo shown in the *News Breakers* article showed sand on the beaches. In fact the 1993 photo shows a situation in 1993 where no sand was present, some 24 years following groin/jetty construction. This was followed in 1994 by a $5.45 million renourishment project, the fruits of which disappeared within several years and had to be redone in 2002 and again in 2005. So from 1973 to 2007, a period of 34 years, nearly $45 million in tax-payer money has had to be spent on the beach east and west of the Fort Macon groin/jetty.



Location	Date	Volume (cy)	Actual Cost	2009 Dollars*
Pea Island	1990	254,955	-	-
Pea Island	1991	282,600	-	-
Pea Island	1992	184,300	-	-
Pea Island	1992	1,078,000	-	-
Pea Island	1993	433,235	-	-
Pea Island	1995	203,191	$1,294,327	$1,806,528.88
Pea Island	1996	500,217	-	-
Pea Island	1997	294,000	$1,159,642	$1,536,861.62
Pea Island	1998	260,183	$637,448	$831,846.18
Pea Island	1999	328,919	$545,515	$696,494.30
Pea Island	2000	419,305	$1,228,564	$1,517,576.19
Pea Island	2001	513,706	$2,568,530	$3,084,977.12
Pea Island	2002	732,852	$2,822,329	$3,337,047.13
Pea Island	2003	1,029,543	$3,860,786	$4,463,173.53
Pea Island	2004	616,448	$2,510,229	$2,826,618.85
Pea Island		7,131,454	$16,627,370	$20,101,123.80

Location	Date	Volume (cy)	Actual Cost	2009 Dollars*
Fort Macon	1961	-	$952,000	$6,772,540.74
Atlantic Beach/Fort Macon	1973	504,266	$414,807	$1,987,233.83
Atlantic Beach/Fort Macon	1978	1,179,600	$1,565,177	$5,106,245.93
Atlantic Beach/Fort Macon	1986	4,168,600	$5,316,038	$10,317,236.56
Atlantic Beach/Fort Macon	1990	-	-	-
Atlantic Beach/Fort Macon	1994	4,664,000	$3,794,727	$5,446,508.67
Atlantic Beach/Fort Macon	2002	209,348	-	-
Atlantic Beach/Fort Macon	2005	2,800,000	$12,900,000	$14,049,903.23
Fort Macon	2007	211,000	$1,184,500	$1,215,160.51
		13,736,814	$26,127,249.00	$44,894,829.47

*The BLS CPI inflation calculator uses the average Consumer Price Index for a given calendar year. This data represents changes in prices of all goods and services purchased for consumption by urban households. This index value has been calculated every year since 1913. For the current year, the latest monthly index value is used.

Figure 1. Aerial photographs of Pea Island (left) and Atlantic Beach/Fort Macon (right) and table of beach renourishment projects for each by year and cost for each island terminus. Note the eroded, cuspate coastline downstream of the Pea Island groin and the eroded coast on the leeside of the Fort Macon groin. (Color for this figure is only available in the online version of this paper.)

That does not seem like a very good investment of precious public tax-payer dollars and moreover totally refutes the argument that groin/jetties are "a" or "the" solution to beach erosion. To the contrary, the case that seems to have been built by this example is that the hardened structures are a major culprit and are a partial cause of the problem.

Mayor Smith also mentions the groin/jetty built at the terminus of Pea Island as another North Carolina success story. Has this been the case for Pea Island? The facts state that from 1990 through 2004, $20.2 million in public tax-payer money has been spent at Pea Island in renourishment projects. The table of the actual facts of renourishment projects and associated costs at Atlantic Beach/Fort Macon and Pea Island are presented in Figure 1. The aerial photos shown were taken in 2009. Clearly Fort Macon will soon require another costly renourishment project. Moreover, the beach to the west of the groin/jetty has undergone a stark recession and will also require costly renourishment. These data are from public records. The total cost of renourishment for Fort Macon and Pea Island has been $64, 905,952 to date.

Mayor Smith also notes in her article that, "These structures have been used successfully in many coastal states for years" (Smith, 2011, p. 3). Again, what are the facts? As shown in Figure 2, the 15 such structures put in place from Ocean City, Maryland, to Boca Grand Pass, Florida (not including North Carolina), have required $778,798,382 in beach-renourishment projects. These numbers are well documented in Riggs (2009) and Riggs and Ames (2011).

The total 17 groin/jetty structures from Florida to Maryland have required expenditures of $843,704,334 up through 2009; this is $49,629,431 per structure (Figure 2). In North Carolina alone the rate of renourishment cost to the public has been $11,180,109/decade or $5,900,055 per groin/jetty per decade. This is a daunting figure for an island such as OIB. Who will pay the documented costs of approximately $6 million per decade? And what land is being protected? If the photographs do not lie, then very few land owners are actually being protected. Certainly the land downstream of the structures will be deprived of sediments, as shown over and over. The classic textbook example of the downstream damage affected by these

Location of Terminal Structure	Volume Emplaced	Cumulative Cost
BOCA GRANDE PASS (FL)	1,336,781	$17,542,500
JOHNS PASS (FL)	13,248,650	$162,417,417
BAKERS HAULOVER (FL)	17,150,775	$38,229,274
CLEARWATER PASS (FL)	10,902,450	$151,791,898
ST. LUCIE INLET (FL)	30,985,280	137,950,278
BIG CARLOS PASS (FL)	360,000	$3,237,280
BLIND PASS (FL)	5,506,700	$11,582,900
NASSAU SOUND (FL)	6,185,096	$10,874,735
PORT CANAVERAL (FL)	15,614,000	$92,748,198
REDFISH PASS (FL)	6,864,600	$20,222,483
ST. AUGUSTINE INLET (FL)	5,465,500	$12,662,600
MIDWAY INLET (SC)	530,700	$2,312,000
ST. HELENA SOUND (SC)	6,012,149	$17,778,553
TYBEE ISLAND (GA)	5,960,000	$9,736,000
OCEAN CITY INLET (MD)	14,366,391	$89,712,266
TOTAL	140,489,072	$778,798,382

Figure 2. Table of Florida, Georgia, South Carolina, and Maryland groins and the renourishment projects required to replace eroded beaches by volume of sediment and cost associated with each project. (Color for this figure is only available in the online version of this paper.)

Figure 3. Aerial photograph of New Jersey shoreline showing eroded, cuspate shoreline downstream of groins. (Color for this figure is only available in the online version of this paper.)

structures is shown for the New Jersey coast in further discussion (Figure 3), a horrifying prospect for a small, 6.5 mi in length, barrier island. Pity the homeowners at the central and west end of OIB, and pity the homeowners of Sunset Beach, an island only 3.5 mi long and in the lee of OIB. Legal experts and banking interests fear that coming property owner law suits will surely bankrupt such small and resource-limited barrier islands. Further, if a groin/jetty is built at the east end of Holden Beach, it will deprive OIB of Cape Fear River sediment effluents as well those emanating from the Lockwood Folly Inlet. Both the Cape Fear River Plume and the Lockwood Folly Inlet Plume turn, on average, toward the west as they out-well onto the adjacent Continental Shelf. Thus OIB beaches will be further starved, as will the Sunset Beach beach.

The message to the public regarding groins and jetties are as follows. (1) Individual snapshots to prove a particular perspective should not be used when the photos simply represent one particular time in a long series of groin/jetty and beach-renourishment projects. (2) The true record of what has actually transpired and what the associated costs have been should be presented. (3) An honest, unbiased effort to understand naturally occurring processes should be made by managers and decision makers. Naturally occurring processes, such as frequent atmospheric storms, will not be denied as to have taken place. (4) Public decision makers, who in many cases have a principal knowledge base that is real estate development and who may have vested interests, should not be spending public funds nor advocating for the expenditure of public funds where a conflict of interest may exist. (5) The public should be fully informed of the folly of building on the tips of barrier islands because these locales are highly naturally unstable and cannot be stabilized. The tips of barrier islands will and must move because the islands must migrate to survive rising sea level and continued atmospheric storms. (6) The North Carolina Legislature nor any other state legislative body should not be so controlled by the real estate and construction lobby that it makes ill-conceived decisions that put the public beaches at risk, which it has done in the case of North Carolina. (7) The banking community should be fully aware of the risks of subsidizing housing at the tips of barrier islands and thus not make building loans for such construction. (8) Sea level is rising and groins and jetties will exacerbate the erosion effects of storms occurring on a higher base of sea level. (9) Cost analyses of the continued costs of counter-acting the damage done by groins and jetties should be conducted using the facts. (10) The tax value and taxes derived from properties purportedly to be protected by the structures should be part of a cost-benefit analysis. The question should be whether the taxes to be derived are sufficient to cover the continuing costs associated with these structures? Here again, we consider public records.

Andy Coburn of Western Carolina University conducted the analysis subsequently summarized. Basically, using the U.S. Army Corps of Engineers, figures of the property that will purportedly benefit from an OIB east-end groin/jetty is shown in the ellipse (Figure 4). This is a government drawn figure. It is ambitious at best, but we will accept it at face value. The total properties in the ellipse number 60. Here we note that the assumption is that the groin/jetty will benefit all OIB properties in the ellipse, but that is not a solid assumption. In fact the aerial photos of Fort Macon, North Carolina, and the New Jersey coast speak to that untruth. Moreover, the structure will hurt all OIB properties to the west of the ellipse. But I digress. (1) The total appraised value of properties inside of the ellipse is $18,100,460 (2009 assessments); (2) the average appraised value/property inside of the ellipse is $301,674; (3) the county tax revenue/year (at 0.305/100) is $55,206; (4) the county tax revenue/property/year is $920; and (5) the total OIB tax revenue/year (at 0.09/100) is $16,290. This cost–benefit analysis begs two questions. (1) How is multimillion dollars of costs of construction a value to the community? Moreover, (2)

Shallotte Inlet/Ocean Isle Beach (within red circle):
Total Properties: 60
(NOTE: Terminal groin assumed to benefit all properties in red)

Assessed Value

2009 Assessed Value of Properties: $18,100,460 ($301,674/property)

2009 Brunswick County Assessed Value: $31,392,480,327.87
Percent of 2009 County Assessed Value: 0.058%

2009 OIB Assessed Value: $2,640,888,866
Percent of 2009 OIB Assessed Value: 0.685%

County Tax Value (@ .305/100)

- 2009 County Ad Valorem Tax Revenue: $95,747,065.00
- 2009 County Ad Valorem Tax Revenue Generated by Properties: $55,206 ($920/Property)
- 2009 County Ad Valorem Tax Revenue Generated by Properties: 0.058%

OIB Tax Value (@ .09/100)

- 2009 OIB Ad Valorem Tax Revenue: $2,376,800
- 2009 OIB Ad Valorem Tax Revenue Generated by Properties: $16,290 ($272/Property)
- 2009 OIB Ad Valorem Tax Revenue Generated by Properties: 0.685%

Occupancy Tax Revenue

- FY 2006-07 OIB Occupancy Tax Received: $1,134,847
- # of Structures Rented: 828 (p19 OIB LUP)
- Occupancy Tax/Structure: $1,371
- Estimated Occupancy Tax Revenue: (60x.33)x$1,371 = $27,145/Yr

Figure 4. Ocean Isle Beach (OIB) North Carolina tax value and tax benefits of proposed OIB groin. The U.S. Army Corps of Engineers projected that 60 properties (in the red ellipse) would be protected by the proposed groin. Andrew Coburn of Western Carolina University conducted an analysis of county and town tax records, which show that these properties 0.058% (or less than six-hundredths of one percent) to the Brunswick County Tax Base and 0.685% (or less than seven-tenths of one percent) to the OIB Tax Base. (Color for this figure is only available in the online version of this paper.)

How do the continuing costs of approximately $6,000,000 per decade a value to barrier islands such as OIB? The answer to both questions is, It is not! The public should vote this ill-conceived, misguided initiative down, resoundingly.

Basically, it should be understood that beach migration is a naturally occurring process. The beaches move when energetic atmospheric storms, which create highly energetic coastal ocean currents and large amplitude waves, then mechanically move sediments along, away from and toward the coast. The Egyptians, Chinese, Greeks, and Romans all understood this. Moreover Native American Indians, the earliest inhabitants of the coastal areas of the eastern seaboard of the United States, understood this. The approach taken by those cultures was to go wherever the beaches were. In fact the Romans were known to create rice fields in the wetlands behind European barrier islands; patties that are still lucrative enterprises today. The inlets, which must move as the islands migrate, are also natural passageways for estuarine-dependent finfish and are heavily used by marine wildlife for food and habitats. Any changes in the inlet functioning will necessarily impact wildlife balances and survival.

Well-intentioned coastal engineers, whose business is construction, have tried many so-called solutions in attempts to take on, deal with, and solve inlet migration, beach movements, and sea-level rise. But all efforts involving groins and jetties have failed. In the mid-1990s, the U.S. National Academy of Sciences (NAS) and the U.S. Park Service (PS) asked a team of expert coastal scientists and engineers to study the issue of the Cape Hatteras Lighthouse, North Carolina, which was under threat of being destroyed by the encroaching Atlantic Ocean. This was after a period over which a series of groins had been built to protect the Lighthouse by stabilizing the Hatteras shoreface and in building out the beaches. Unfortunately the erosion in front of the Lighthouse was exacerbated by the groins, and the Expert Panel agreed that the only viable solution was to move the Lighthouse. The NAS and PS agreed with the recommendation; the Lighthouse was moved, and the whole issue has gone away with movable beach resources being enjoyed by the public.

Given the well-known effects of the passages of winter storms in causing coastal erosion and inlet migration, one would assume that the frequency occurrence of winter storms on an annual basis should correlate with any beach erosion and or beach-renourishment projects. As it occurs, Riggs and Ames (2011) meticulously created an "erosion *vs*. accretion" profile for Pea Island, North Carolina, using a combination of North

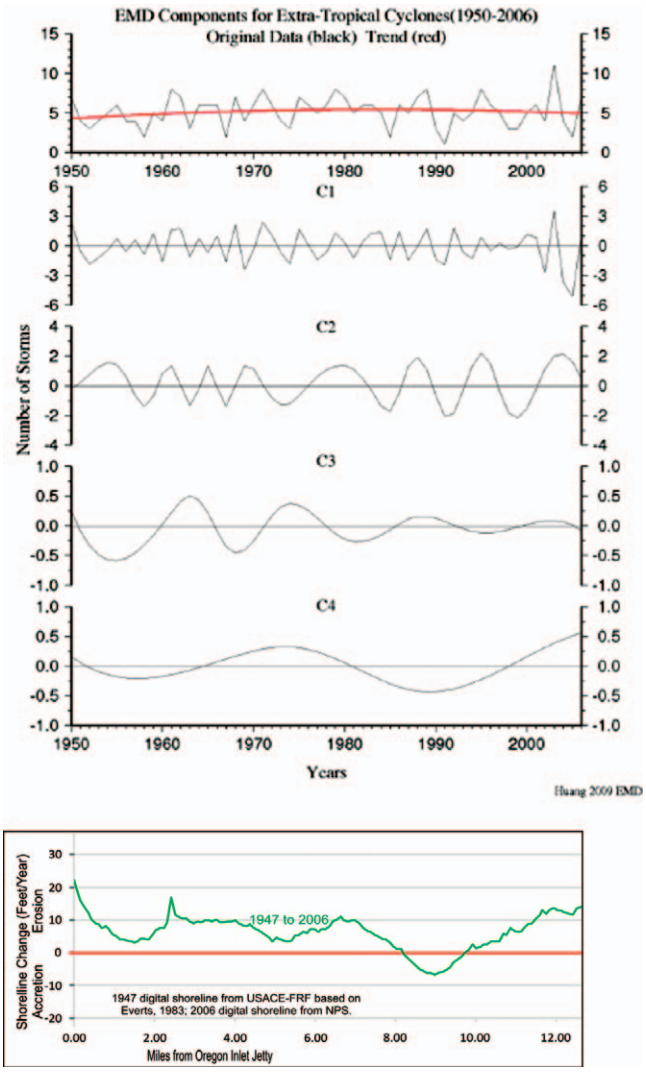


Figure 5. Rate or shoreline erosion (above red line) and or accretion (below red line) of the coastline at Pea Island from 1947 through 2006 *vs*. the ensemble empirical mode decomposition (EEMD) modal decomposition of the frequency of occurrence of atmospheric winter storms in the vicinity of Cape Hatteras, North Carolina. (Color for this figure is only available in the online version of this paper.)

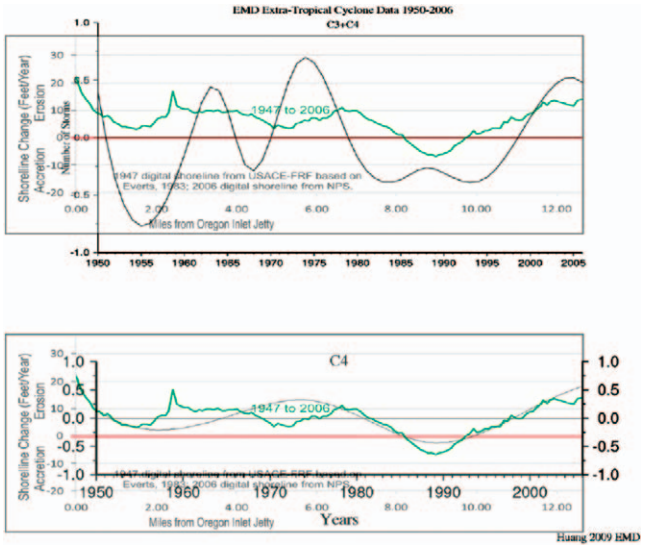


Figure 6. Rate of erosion/accretion of the coastline at Pea Island *vs*. (upper panel) the decadal plus multidecadal frequency of occurrence of winter storms (Modes C3 + C4) from Figure 5 and (lower panel) the multidecadal frequency of occurrence (Mode C4) from Figure 5. (Color for this figure is only available in the online version of this paper.)

Carolina Department of Transportation aerial photographs and beach surveys over the years 1947 to 2006. However, if one looks at the beach renourishment campaigns that have been staged by North Carolina for Pea Island (see Figure 1), one sees that from 1990 to 2005 there has been a series of yearly projects peaking in 1992 with 1.27 million yd of sediment dumped on the beaches. So a one-to-one annual comparison (Figure 5) is not mathematically tractable. However, if we conduct an empirical ensemble modal decomposition (Huang *et al*., 1998) of the annual winter storm data set we find that there is a long period mode of about 30 years (Intrinsic Mode Function [IMF] mode C4). If one compares the Riggs erosion-accretion data-time series, one sees a clear relationship that suggests that over the long haul, the erosion *vs*. accretion curve is in keeping with the variability of the frequency of occurrence of U.S. east coast winter storms (Figure 6, lower panel). Unfortunately, higher frequency modes of variability, such as IMF modes (C3 + C4) *vs*. the erosion-accretion curve (also Figure 6, upper panel) are masked by renourishment projects. It is of note that the Fort Macon time series of renourishment projects (Figure 1) seems to align very well with IMF mode C2, which nominally has about a 7–8 year cycle. This suggests that if the renourishment strategy of putting sediments on the Fort Macon beaches during particularly energetic storm years or actually a sequence of them, then there is a clear argument that at a maximum, beach renourishment attributable to the combined effects of winter storm occurrence and the presence of groin/jetties will require major renourishment expenditures on no less than every 7 years and more likely more frequently.

The structures proposed in places such as Figure Eight Island, Holden Beach, and OIB are on the down-drift side of the neighboring inlet. A shore-perpendicular structure, placed at the down-drift side of an inlet, will block the natural flow of sand onto the island where the structure is located. This will cause an increase in shoreline erosion in front of oceanfront homes down-drift of the structure. Protecting homes at the inlet will be at the expense of a larger number of homes down the beach.

The unfettered flow of sand through natural inlets is an important mechanism maintaining barrier island health. Blocking this flow of sand will inhibit the ability of the barrier island to respond to rising sea level and storms. Also, groins can impact near-shore circulation by directing currents offshore, especially during storms. Groins can be particularly destructive following storms if a significant portion of the nourishment project is transported offshore, leaving the groin uncovered.

During this period the groin will block all along-coast transport until the cell is filled in again.

CONCLUSIONS

The lessons learned by the previous examples presented are as follows. (1) The public will use beaches wherever they are. (2) Sediments are not lost from the total barrier island beach system during storm passage; rather they are relocated within the system. (3) Inlets, the tips of islands, are sources of sediments that should be used naturally by the barrier island system *per se* to maintain themselves. (4) There should be a moratorium on the public policy of allowing building on the ends or tips of barrier islands. Basically these lands should be viewed as being in a continual state of migration and should be allowed to move as necessary. Inlets do not close, they just relocate. (5) Hardened structures will not stabilize inlets or eliminate erosion, rather they will cause erosion and thus should be banned in perpetuity. (6) Publicly elected officials should tell the whole story and not cherry-pick facts for their own use, and if they do, they should be held accountable. (7) Public funds should not be used for either groin/jetty or renourishment projects. This is a misuse of public revenues, and managers who do so should be held accountable.

ACKNOWLEDGMENTS

The author acknowledges the tables and imagery provided by Dr. S. Riggs of East Carolina University (ECU) and Mr. A. Coburn (Western Carolina University, WCU). The author also acknowledges the many discussions held with scientists Dr. O. Pilkey of Duke University (DU), Dr. R. Young (WCU), Dr. J.P. Walsh (ECU), Dr. Steve Culver (ECU), Dr. Dave Mallinson (ECU), Dr. P. Peterson (University of North Carolina-Chapel Hill, UNC-CH), Dr. Tony Rodriguez (UNC-CH), Dr. M. Stutz (Meredith College), and Dr. D. Heron (DU). The collective group of scientists has stated, "We are not antidevelopment. Nor are we an environmental lobby. We are simply electing to play our role in helping the state develop sound, science-based policy." Mr. J. Epps is thanked for acquiring and processing the storm data from the National Oceanic & Atmospheric Administration–National Climatic Data Center.

REFERENCES

Huang, N.E.; Shen, Z.; Long, S.R.; Wu, M.C.; Shih, E.H.; Zheng, Q.; Tung, C.C., and Liu, H.H., 1998. The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis. *Proc. Roy. Soc. Lond*., 454A, 903–993.

Lewis, L., 2012, Holden Beach OKs terminal Groin Pursuit. *Brunswick Beacon,* January 12 2012, pp. 9, 15.

Riggs, S.R., 2009. Eye of the Human Hurricane: Pea Island, Oregon Inlet, and Bodie Island, northern Outer Banks, North Carolina. *In:* America's Most Vulverable Coastal Communities, Geological Society of America Special Paper 460, pp. 43–72.

Riggs, S.R. and Ames, D.V., 2011. Consequences of human modification in Oregon Inlet to the down-drift Pea Island, North Carolina Outer Banks. *Southeastern Geology*, 48(3), 103–128.

Smith, D., 2011. Mayor's Muse. *Newsbreakers*, (1)1, 3.