Detailed Analysis of Beach Nourishment and its Impact on the Surfing Wave Environment of Brevard County, Florida

by
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Introduction

• Significant debate regarding impact of beach nourishment projects on the surfing wave environment

• Surfing organizations have lobbied to modify or block coastal engineering projects which threatened popular surf breaks

• Analyze historical and ongoing beach nourishment projects in Brevard County, Florida

• Determine impact to North Reach and South Reach surfing wave environments
Management Reaches of Brevard County, FL

North Reach – Port Canaveral (R-0) to Patrick AFB (R-54)

Patrick Air Force Base – (R-54 to R-75)

Mid Reach – Patrick AFB (R-75) to Indialantic (R-118)

South Reach – Indialantic (R-118) to Melbourne Beach (R-139)

South Beaches – Melbourne Beach (R-139) to Sebastian Inlet (R-219)

Data: SIO, NOAA, U.S. Navy, NGA, GEBCO
90 µm = 0.09 mm = 3.5 phi

1971 Native Shoreline
Mean – Fine Sand
Mode – Very Fine Sand
(Wentworth Classification)
North Reach Nourishment Methods:

Port Canaveral Harbor

Sand Bypass

1972: 200,000 yd$^3$
1995: 783,000 yd$^3$
1998: 1,035,000 yd$^3$
2007: 750,000 yd$^3$
2010: 650,000 yd$^3$

(Brevard County, 2011)
North Reach
Nourishment Methods:

Port Canaveral
Trident Basin Dredge
1974: 2,850,000 yd$^3$

(Brevard County, 2011)
North Reach Composite Grain Size Distributions 1971-1986

- 1971 R 17-22 Composite
- 1977 R 17-22 Composite
- 1986 R 1-16 Composite

1971 – 1986 Shoreline Mean – Fine Sand Mode – Very Fine Sand (Wentworth Classification)

(Wentworth Classification)
Brevard County Composite Grain Size Distributions 1989

- R-36 Cocoa Beach Composite (North Reach)
- R-64 Patrick AFB Composite (Patrick)
- R-93 Satellite Beach Composite (Mid Reach)
- R-125 Indiatlantic Composite (South Reach)
- Brevard County Beaches Composite 1989

(Olsen, 1989)
North Reach Composite Grain Size Distributions 1971-1989

125 µm = 0.125 mm = 3.0 phi

1989 Shoreline Mean – Fine Sand Mode – Fine Sand
(Wentworth Classification)

USACE, 1987 (Olsen, 1989)
R-36 Cross Shore Grain Size Distributions 1989

Class Weight (%)
Grain Size (µm)

1989 R36 Dune
1989 R36 +3 ft Berm
1989 R36 -3 ft MLW
1989 R36 -6 ft Trough
1989 R36 -9 ft
1989 R36 -12 ft

1989 Shoreline Means – Very Fine / Fine Sand
Modes – Very Fine / Fine Sand
(Wentworth Classification)

(Olsen, 1989)
North Reach Nourishment Methods:

Port Canaveral Harbor & Channel Dredge

1992: 79,000 yd$^3$
1993: 50,000 yd$^3$
1994: 68,000 yd$^3$
1995: 122,000 yd$^3$

(Brevard County, 2011)
Port Canaveral Channel Borrow Site Composite Grain Size Distribution

1989 R36 Composite
1989 R36 -12 ft
1994 Borrow: Port Canaveral Channel

1994 Channel Fill
Mean – Fine Sand
Mode – Very Fine Sand
(Wentworth Classification)

(CAL-TECH, 1994) (Olsen, 1989)
North Reach Nourishment Methods:

Truck Haul from Upland Sources

1994: 100,000 yd$^3$
1996: 40,000 yd$^3$

(Brevard County, 2011)

Port Canaveral
North Reach
Nourishment Methods:
Port Canaveral Harbor
Sand Bypass

1972: 200,000 yd$^3$
1995: 783,000 yd$^3$
1998: 1,035,000 yd$^3$
2007: 750,000 yd$^3$
2010: 650,000 yd$^3$

(Brevard County, 2011)
Cape Canaveral AFS Borrow Site Composite Grain Size Distribution

1986 R 1-16 Composite
1989 R36 Composite
1994 Borrow: Cape Canaveral AFS

1994 Cape AFS Fill
Mean – Very Fine Sand
Mode – Very Fine Sand
(Wentworth Classification)

Fill Template
Port Canaveral Harbor Sand Bypass

Natural Foreshore Slope \approx 1:50

Template Foreshore Slope = 1:25  (FDEP, Nov 2004)
North Reach Nourishment Methods:
Brevard County Shore Protection Project

Port Canaveral

Canaveral Shoals II

2001 – 2,798,000 yd³
2005 – 754,600 yd³

(Brevard County, 2011)
South Reach Nourishment Methods: Brevard County Shore Protection Project

Canaveral Shoals II

2003 – 1,346,000 yd$^3$
2005 – 578,910 yd$^3$
2010 – 636,000 yd$^3$

(Brevard County, 2011)
Brevard County Composite Grain Size Distributions

250 µm = 0.250 mm = 2.0 phi

1998 Canaveral Shoals II Fill
Mean – Medium Sand
Mode – Medium Sand
(Wentworth Classification)

Median Grain Size Δ
Fill – R36 = + 200 µm
Recommended = ± 10 µm
(USACE CEM, 2007)

(Olsen, 1989) (USACE, 2006)
Fill Template
Brevard County Shore Protection Project

Natural Foreshore Slope \(\approx 1:50\)

Template Foreshore Slope \(= 1:15\)  (USACE, 1996)
North Reach Composite Grain Size Distributions 1989 - 2005

- 1989 R36 Composite
- 2001/2005 Fill Composite
- 2005 R21/R29 Composite

2005 Shoreline
Mean – Medium Sand
Mode – Medium Sand
(Wentworth Classification)

Class Weight (%) vs. Grain Size (µm)

Use beach fill material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system.

Characteristics include the sediment properties of grain size distribution, color and mineral composition (quartz and carbonate) and bulk properties of cementation and compaction.
Research Findings

Fill material used in the 2001 and 2005 fill projects did not maintain the general character of the sediment occurring in the existing North Reach coastal system.

The mean & median grain size for the fill sediment was triple that of the existing beach while the mode was double.

The result was a nourished beach with a very different character than the existing beach.
North Reach
Nourishment Methods:

Port Canaveral Harbor
Sand Bypass

1972: 200,000 yd$^3$
1995: 783,000 yd$^3$
1998: 1,035,000 yd$^3$
2007: 750,000 yd$^3$
2010: 650,000 yd$^3$

(Brevard County, 2011)
North Reach Composite Grain Size Comparisons 1989 - 2011

- 1989 R-36 Composite
- 2005 R21/R29 Composite
- 2011 R36 Composite

2011 Shoreline Mean – Fine Sand Mode – Fine Sand (Wentworth Classification)

R-36 Cross Shore Grain Size Distributions 1989 and 2011

Class Weight (%) vs. Grain Size (µm)

1989 R36 Dune
2011 R36 Dune
1989 R36 Berm
2011 R36 Berm
1989 R36 MHW
2011 R36 MHW
1989 R36 MLW
2011 R36 MLW
1989 R36 Trough
2011 R36 Trough
1989 R36 -12ft
2011 R36 -10ft

2011 Shoreline Modes
Offshore – Very Fine Sand
Waterline – Fine Sand
Backshore – Medium Sand

(Olsen, 1989) (Hearin, 2011)
Beach Modal State

Determined using Dimensionless Fall Velocity (Dean Number)

\[ \Omega = \frac{H_b}{T W_s} \]

where:
- \( H_b \) - breaking wave height
- \( T \) - wave period
- \( W_s \) - sediment fall velocity (Jimenez & Madsen, 2003)

Modal State may be used to predict and quantify impact of beach nourishment on the surfing wave environment.

(Wright & Short, 1984)
(Benedet L. , Finkl, Campbell, & Klein, 2004)
(Benedet, Pierro, & Henriquez, 2007)
## Modal Beach State

<table>
<thead>
<tr>
<th>$\Omega$</th>
<th>Modal Beach State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt; 1$</td>
<td>Reflective</td>
<td>surging breakers, constant wave reflection, no bars, steep beach profiles, coarse to medium sediment, narrow surf zones</td>
</tr>
<tr>
<td>2</td>
<td>Intermediate-reflective</td>
<td>surging to plunging breakers, cellular circulation with rip currents, variable beach profiles, medium to coarse sediment</td>
</tr>
<tr>
<td>3</td>
<td>Intermediate</td>
<td>plunging breakers, cellular circulation with rip currents, variable beach profiles, medium sediment</td>
</tr>
<tr>
<td>4</td>
<td>Intermediate</td>
<td>plunging breakers, cellular circulation with rip currents, variable beach profiles, medium sediment</td>
</tr>
<tr>
<td>5</td>
<td>Intermediate-dissipative</td>
<td>plunging to spilling breakers, cellular circulation with rip currents, variable beach profiles, medium to fine sediment</td>
</tr>
<tr>
<td>$&gt; 6$</td>
<td>Dissipative</td>
<td>spilling breakers, multiple low relief bars, flat beach profiles, fine to very fine sediment, wide surf zones</td>
</tr>
</tbody>
</table>

(Wright & Short, 1984)  
(Benedet L., Finkl, Campbell, & Klein, 2004)  
(Benedet, Pierro, & Henriquez, 2007)
North Reach Modal Beach States

Composite Shoreline
Composite Fill Port Channel (1994 sample)
Composite Fill Cape AFS (1994 sample)
Composite Fill Canaveral Shoals II (1998 sample)
Composite Fill Cape AFS (2003 sample)

Dimensionless Fall Velocity ($\Omega$)

Date

Reflective
$\Omega < 1$

Intermediate
$6 > \Omega > 1$

Dissipative
$\Omega > 6$

Surfing Wave Parameter Analysis

• Dally wave transformation and breaking algorithm (Dally, 1992)
• 6 year synthetic wave data set (Surfbreak Eng, 2008)
• 9 survey profiles at R-36 from 2000 to 2010 (FDEP, 2011)
• Breaker height and depth
• Surf zone width
• Sea bed slope
• Breaker type over barred profiles (Smith & Kraus, 1990)
• 3 Tidal datums (MLLW, MSL, MHHW)
• Coded in Matlab® adapted from Klug (Klug, 2010)
North Reach R36 Mean and Std Dev of Surf Zone Widths

Survey Profile

- MLLW
- MSL
- MHHW

Surf Zone Width (ft)
North Reach Monument R36 Median Breakpoint at MLLW

Nov 2000 SZW = 220 ft
Jan 2001 SZW = 170 ft
North Reach Monument R36 Median Breakpoint at MHHW

Nov 2000 SZW = 210 ft
Jan 2001 SZW = 50 ft
North Reach Monument R36 Median Breakpoint at MLLW

Nov 2000 SZW = 220 ft
Aug 2010 SZW = 210 ft
North Reach Monument R36 Median Breakpoint at MHHW

Elevation (ft) NAVD88

-20 -15 -10 -5 0 5 10 15

Horizontal Station from Monument (ft)

-20 -15 -10 -5 0 5 10 15 20

Nov 2000 SZW = 220 ft
Aug 2010 SZW = 180 ft
North Reach R36 Breaker Type Distributions at MSL

- Collapsing/Surging
- Plunging
- Spilling

Survey Profile:
- Nov-00
- Jan-01
- Jun-04
- Mar-05
- Apr-05
- May-06
- Aug-07
- Jul-08
- Aug-10
North Reach R36 Breaker Type Distributions at MHHW

- Collapsing/Surging
- Plunging
- Spilling

Survey Profile:
- Nov-00
- Jan-01
- Jun-04
- Mar-05
- Apr-05
- May-06
- Aug-07
- Jul-08
- Aug-10

Distribution Profile:
- Nov-00: 70% Spilling, 30% Plunging
- Jan-01: 60% Spilling, 40% Collapsing/Surging
- Jun-04: 50% Spilling, 50% Plunging
- Mar-05: 40% Spilling, 60% Collapsing/Surging
- Apr-05: 30% Spilling, 70% Plunging
- May-06: 20% Spilling, 80% Plunging
- Aug-07: 10% Spilling, 90% Plunging
- Jul-08: 0% Spilling, 100% Plunging
- Aug-10: 0% Spilling, 100% Plunging
Impacts to Surfing Wave Environment

North Reach Pre Fill (Before 2001)

- Dissipative beach, flat profile, low sand bars
- Wide surf zone width at all tides
- Primarily low intensity spilling breakers at all tides
- Occasional plunging breakers at higher tides
- Favor longboard riders
Impacts to Surfing Wave Environment

North Reach - Post Fill (2001 to 2008)

• Intermediate beach, steep profile, variable sand bars
• Very tidal dependent surf zone width
• Low intensity spilling breakers at lower tides
• Plunging breakers at higher tides
• Occasional collapsing breakers at highest tides
• Very short rides at high tide favor shortboarders
Impacts to Surfing Wave Environment
North Reach – 2008 to Present

• Finer updrift fill in 2007 & 2010 has returned beach to dissipative state
• Surfing environment returning to pre fill conditions
• Coarser fill from 2001 & 2005 still entering surf zone during high erosion events
Coastal Protection

• North Reach Shore Protection Project and Canaveral Harbor Sand Bypass Project have increased the total shoreline volume of the North Reach by 2.16 million cubic yards and increased the shoreline position 90 -120 ft seaward of the pre fill values in 2000. (Olsen, 2010)

• The beaches in the North Reach are much wider with a healthier dune system than before the fill projects began in 2001.

• Beach nourishment projects must be considered a success from a coastal protection point of view.
Goals

• Maintain the original nature of the beach in the North Reach

• Avoid future adverse impacts to the surfing wave environment in the North Reach
All future nourishments in the North Reach should adopt the flatter fill template (1:25) used for the Canaveral Harbor Sand Bypass Projects.

The flatter slope is a much better match for the natural slope of the seabed in the North Reach.
Use the Cape Canaveral Air Force Station borrow site for all future North Reach nourishment projects.

Cape Canaveral AFS borrow site has been shown to be a much better match for the native beach sediment of the North Reach.
Reconsider a permanent sand bypass system at Port Canaveral, an idea that has been under consideration for over 40 years (USACE, 1987).

- Promote a more natural flow of sediment into the North Reach littoral cell.

- Reduce the need for disruptive dredge and fill projects.

- Reduce negative impacts to the natural character of the beach and the surfing wave environment.
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Presentation References


