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by James Houston, Engineer Research and Development Center, Corps of Engineers

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by Michelle Malyn
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Mobility of Unexploded Ordnance using Spherical Surrogates on the Beach Face

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Read about the research taking place at UD's Center for Applied Coastal Research on munitions in coastal environments and the creation of a model that decision makers can use for risk assessment.

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The Fate of Beach Nourishment Sand Placed on the Florida East Coast

James Houston, Engineer Research and Development Center, Corps of Engineers

Over 100 million yd^3 of sand have been placed on Florida east coast beaches since large-scale beach nourishment started in 1970. Where is it now? Has it largely disappeared, or is it largely in place, having increased beach width as much as expected?

There are not bathymetric measurements with sufficient accuracy to track beach nourishment sand movement over decades. However, equilibrium profile theory, used in beach nourishment design and sediment budgets, relates shoreline advance or retreat, *X*, due to adding a sand volume, + V, (e.g., beach nourishment) to the active littoral zone or removing sand volume, - V, (e.g., inlet ebb shoal growth) by the following equation:

$$X = \frac{\pm V}{[(h_* + B) * L]} \qquad \text{Equation (1)}$$

Professor Bob Dean developed the notation with h_* being closure depth, *B* beach berm elevation, and *L* the length of the shoreline receiving or losing sand.

Shoreline change, *X*, caused by relative sea level rise, *S*, also can be estimated based on equilibrium profile theory and is given by:

$$X = \frac{-(S * W_*)}{(h_* + B)} \qquad \text{Equation (2)}$$

W_* is the distance from the landward end of the beach berm to closure depth. Average values of h_* and *B* for each county are taken from the literature, and W_* is determined using a Florida Department of Environmental Protection (FDEP) data base.

Estimates will be made of sand volumes added or removed from the active littoral zone by beach nourishment, longshore transport, and inlets and also the level of sea level rise over the period of beach nourishment. Equations (1) and (2) will then be used to estimate shoreline changes due to sand addition or removal and sea level rise and these changes compared to measured shoreline changes to provide insight into the fate of beach nourishment sand.

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Beach nourishment adds sand to the active littoral zone that extends over the distance W_*. Bypassing sand around inlets is an important and necessary process to continue longshore sand movement, but it does not add new sand to the active littoral zone and is not beach nourishment. Similarly, mining sand from inlet shoals or dredging navigation channels and placing the sand on beaches is not beach nourishment, because the shoals or navigation channels eventually refill, starving adjacent beaches of sand. For example, 800,000 yd^3 of sand were removed from the Lake Worth Inlet ebb shoal in 1995, and placed on downdrift beaches. However, by 2000, the ebb shoal volume had completely recovered as sand from longshore transport refilled the mined area, starving downdrift beaches and resulting in no net sand gain after 5 years. Therefore, sand placement on beaches through shoal sand mining or dredging is actually a long-term method of sand bypassing.

About 15% of beach nourishment has been placed in Nassau County and in Duval County south of the St Johns River entrance. St Johns County has had only sand bypassing from the St Augustine navigation entrance and ebb shoals, Flagler County has never been nourished as of 2017 and Volusia County has had only small bypassing of dredged sand. Federal lands that have not been nourished extend for about the first 30 miles of Brevard County up to Port Canaveral. Therefore, beaches from St Johns County to Port Canaveral have not been nourished and are not considered in the analysis. About 85% of all beach nourishment has been placed on the shoreline from Port Canaveral to Government Cut in Dade County, and this complete shoreline is in the analysis. Using data published in 2018 by FDEP, Table 1 shows nourishment volumes and time periods by county along with the total placement of 108 million yd^3.

County	Volume (million yd^3)	Period of Nourishment
Nassau	8.5	1994 - 2016
Duval	7.7	1978 - 2017
Brevard	12.5	1995 - 2017
Indian River	1.7	2003 - 2016
St Lucie	6.1	1971 - 2016
Martin	20.5	1973 - 2016
Palm Beach	23.2	1973 - 2017
Broward	10.0	1970 - 2017
Dade	17.8	1975 - 2016
Total	108.0	

Table 1. Beach nourishment volumes and time periods.

The effect of longshore transport on shoreline change was determined by analyzing the addition or removal of sand at boundaries of the shorelines analyzed. During the period of beach nourishment, a sand volume of 4.7 million yd^3 was mechanically bypassed from the St Marys River entrance into Nassau County, simulating the addition of longshore transport sand. However, during the same period, longshore transport resulted in a loss out of the County of 6.7 million yd^3, producing a net deficit of 2.0 million yd^3. Similarly, about 4.7 million yd^3 of sand was bypassed around the St Johns River entrance in Duval County, but the County lost 5.8 million yd^3 due to longshore sand transport out of the County for a net loss of 1.1 million yd^3. About 3.8 million yd^3 of sand was mechanically bypassed around Port Canaveral for a net gain in Brevard County, and about 1.0 million yd^3 was lost during the period of beach nourishment to the navigation channel at Government Cut in Dade County.

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The sum of the gains and losses due to longshore transport at boundaries in the four counties equals - 0.3 million yd^3. This is negligible compared to 108 million yd^3 of beach nourishment sand. Longshore transport shapes the shoreline by causing shoreline accretion updrift of inlet structures and erosion downdrift, but has had little net effect on the total sand volume entering or exiting the shoreline being analyzed.

Before 1970, inlets cut or structured for navigation diverted approximately 200 million yd^3 of sand from the active littoral zone to shoals and caused huge downdrift shoreline recession. However, Dombrowski and Mehta (2001) showed that inlet shoal volumes stabilize after about 30 years. Most inlets on the east coast have not been modified for at least 30 years, but four have been modified, causing sand to move from the active littoral zone to shoals. Modifications to St Lucie Inlet in Martin County, Lake Worth and South Lake Worth Inlets in Palm Beach County, and Baker's Haulover Inlet in Dade County have caused sand losses to the active littoral zone of 5.9, 0.9, 3.3, and 0.7 million yd^3 respectively during periods of beach nourishment. Summing yields a total sand loss of approximately 10.8 million yd^3. Inlets will have a lessor effect on sand losses in the future because they are no longer being modified significantly.

The Fernandina Beach tide gauge in Nassau County is the only gauge on the Florida east coast that recorded sea level rise during the entire period of beach nourishment from 1970-2017, measuring an average relative sea level rise of 2.72 ± 0.35 mm/yr. Worldwide sea level rise would not vary much along the Florida east coast over the almost 50 years of the analysis. Therefore, this rate of sea level rise is representative of the rise along the Florida east coast, and when multiplied by periods of beach nourishment, gives, ΔS, for each county in Equation (2).

Data on sand volumes and sea level rise during periods of beach nourishment are used in Equations (1) and (2) to estimate shoreline changes in each county due to beach nourishment, longshore transport, inlets, and sea level rise.

Florida has excellent historical shoreline position change data measured about every 1000 ft along the Florida east coast. At each measurement location, the analysis starts at the first shoreline position measurement before the year of the first beach nourishment in a county and ends at the last shoreline measurement date in 2016 or 2017.

Table 2 compares estimated shoreline change based on Equations (1) and (2) and measured shoreline change (total is weighted by shoreline length). The only large difference is for St Lucie County, but only 7% of its shoreline has been nourished. Moreover, estimated shoreline changes are within standard deviation uncertainties for all counties including St Lucie County. Table 2 shows that 54% of the total analyzed shoreline was nourished. Nourished beaches gained an average width of 118 ft and unnourished beaches (46%) gained 46 ft in width as a result of movement of about 25% of the beach nourishment sand to adjacent unnourished beaches.

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County	Estimated (ft)	Measured (ft)	% Difference	% Nourished
Nassau	76	87	- 14	100
Duval	118	137	- 16	100
Brevard	52	49	6	43
Indian River	15	16	- 7	55
St Lucie	46	61	- 33	7
Martin	104	117	- 13	50
Palm Beach	73	68	7	43
Broward	94	92	2	73
Dade	246	257	- 4	92
Total	80	84	- 5	54

Table 2. Comparison of estimated and measured shoreline change and percentage of the shoreline with beaches that have been nourished.

Figure 1 shows that beach nourishment dominates shoreline change for the entire shoreline. If beach nourishment were the only process affecting the shoreline, the shoreline would have advanced an average of 104 ft. Inlets and sea level rise reduce the 104 ft to 80 ft, which compares very favorably with the measured change of 84 ft (the shoreline change due to longshore transport is about 0.3 ft, and with results rounded to the nearest foot, rounds to zero).

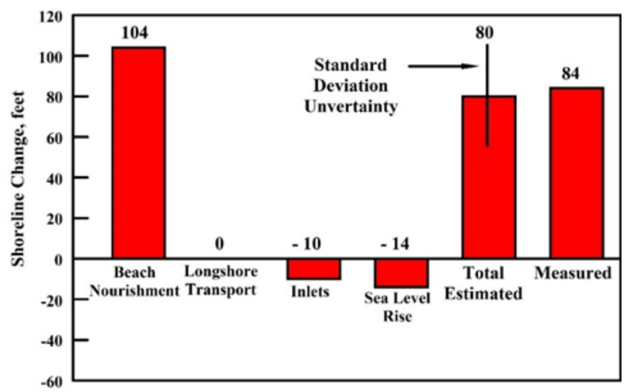

Figure 1. Estimated shoreline change from 1970-2017 caused by the four processes and shoreline change for the total shoreline compared to measured shoreline change.

The fate of beach nourishment sand is shown in Figure 2. (next page) Of the beach nourishment sand placed, 68% remains on nourished beach profiles, 22% is on profiles of adjacent beaches, and 10% has been lost to inlets.

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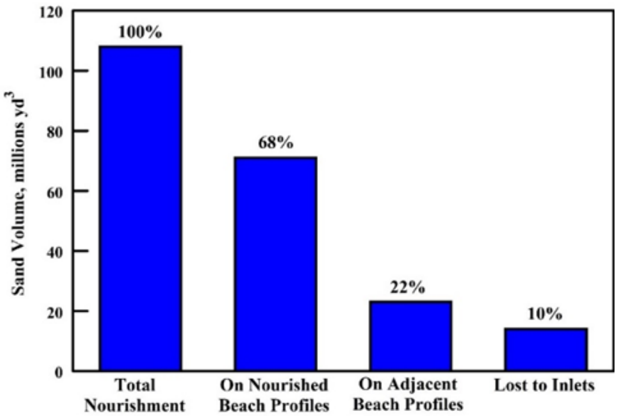

Figure 2. 90% of beach nourishment placed from 1970-2017 is still on beach profiles.

Figure 1 shows that from 1970-2017 beach nourishment had an 8 times greater effect on shoreline change than did sea level rise (104 ft versus 14 ft). Beach nourishment started in 1970 at a relatively small rate and reached a reasonably steady rate by 1978. During the 40 years from 1978-2017, 96 million yd^3 of sand was placed on east coast beaches, which is 2.40 million yd^3/yr. Shoreline change due to beach nourishment and sea level rise are equal when Equations (1) and (2) are equal, which gives:

$$S = \frac{V}{[W_* * L]} \tag{3}$$

Inputting V, W_*, and L values into Equation (3) and converting to metric units and an annual rate gives a sea level rise rate of 15.9 mm/yr, at which point shoreline recession matches accretion from beach nourishment. The Intergovernmental Panel on Climate Change (IPCC) has an 11.2 mm/yr most probable sea level rise rate in 2100 for its worst-case scenario with an upper uncertainty limit of 15.7 mm/yr, which would almost offset beach nourishment in 2100. However, even for this upper limit of the worst scenario, beach nourishment would dominate over sea level rise for the 82 years before 2100, and beaches would widen until then. Figure 3 (next page) shows that it would take about another 50 years for sea level rise to erode the shoreline advance from 2018-2100 back to its 2018 position because it would still have to contend with beach nourishment.

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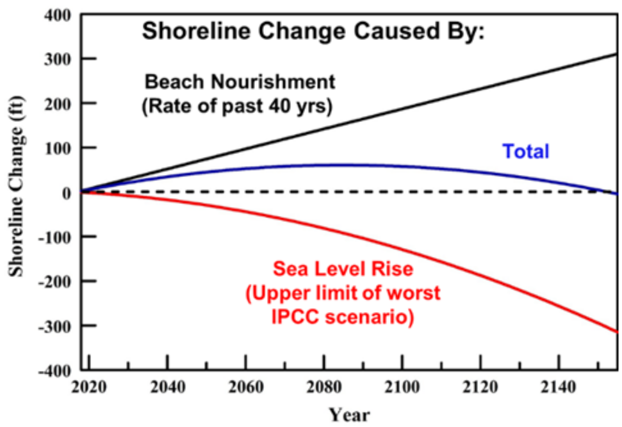

Figure 3. Shoreline change caused by beach nourishment and sea level rise.

Figure 1 shows that had beach nourishment not occurred, beaches would have narrowed by 24 ft since 1970, but instead they actually widened a measured 84 ft. This net change of 108 ft has greatly increased infrastructure protection from storm damage. Based on recorded data, Professor Bob Dean showed that an increase of beach width of only 50 ft almost eliminates damages landward of the Florida construction control line. A study by Florida Atlantic University of damage during the 2004 and 2005 hurricanes in Florida showed that nourished beaches prevented a loss of $1.8 billion in property values in the eight counties that were affected.

The difference of 108 ft in average beach width produced by beach nourishment also has had a huge positive impact on the Florida economy, because revenues from tourism have been shown to increase with increasing beach width. There are almost seven times as many Florida beach tourists today as there were than in 1970, and as a result, Florida has become the number one tourist destination in the world with its tourism industry now its leading employer and beaches its number one tourist attraction.

Beach nourishment works. Nourishment on the Florida east coast has been highly successful with nourished beaches gaining 118 ft in width since 1970 and adjacent beaches that have never been nourished gaining 46 ft in width, increasing storm protection and greatly improving beach recreation. Of the 108 million yd^3 of sand placed on Florida east coast beaches from 1970-2017, 90% of it is on profiles of nourished or adjacent beaches and 10% has been lost to inlets. Moreover, beach nourishment easily offset sea level rise from 1970 -2017, and if placed at the rate of the past 40 years, offsets sea level rise to 2100 and beyond.

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Sebastian Inlet District Dredging, Channel Maintenance, Sand Bypass and Beach Renourishment Project Ongoing

Ferreira Construction of Stuart, selected during a competitive bid process managed by Applied Technology Management (ATM), began dredge operations in January as part of a two-phase dredging, channel maintenance, sand bypass and beach renourishment project for the Sebastian Inlet District. Ferreira Construction will hydraulically dredge 150,000 cubic yards of sand from the inlet's sand trap, a 42-acre depression within the inlet, and 3,120-foot navigation channel leading to the Intracoastal Waterway.

Ferreira Dredge over trap

The State's Beach Management Act requires Sebastian Inlet District to bypass sand onto the northern Indian River County beaches that migrates into the inlet system. While typical bypass projects dredge sand from an inlet system and pump it offshore to put the sand back into the natural sand transport system, the Commission has actively chosen to engage in projects that more resemble traditional beach renourishment because of the environmental and economic significance of our beaches, designing and constructing a template to enhance the dunes and upper berm.

Ferreira fusing pipe at R-8

The 19-week project will move 120,000 cubic yards of beach quality sand to a one and a half mile stretch of downdrift beaches starting just North of McLarty Treasure Museum and continuing South past the Ambersand Beach access (R-10 to R-17) as part of beach renourishment efforts in Indian River County during phase I. An additional 30,000 cubic yards of material will be stockpiled in the Sebastian Inlet District's Dredged Material Management Area (DMMA) for emergency beach fill and dune repair during phase II.

"Channel maintenance, sand bypass and beach renourishment projects will take place every four to five years since we expanded the sand trap in 2014 and we consistently monitor the accumulation of sand within the inlet system through the data we collect in partnership with Florida Institute of Technology and semi-annual bathymetric surveys," said Martin Smithson, Sebastian Inlet District administrator retiring at the end of March. "No other inlet in Florida has the volume of data we do in analyzing coastal processes and the movement of sand through the system."

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Total project cost is $2,945,000 and Sebastian Inlet District officials have applied for cost-share funding available through Florida Department of Environmental Protection (FDEP) and specifically earmarked for coastal and inlet management by the Florida State Legislature. If awarded, 75% of the project could be covered by state funds.

“We are always seeking out ways to manage the District’s budget in a fiscally responsible way and we’ve been able to obtain in excess of $8M in cost-share funding from various sources in the last 15 years,” said Smithson. “In my time here, the Commission has significantly lowered the millage rate paid by property owners within the District’s boundaries.”

The District and its contractors work closely with officials at FDEP and the Army Corps of Engineers to obtain needed permits and conduct important environmental monitoring that takes place pre-, during and post-project. Ongoing turbidity monitoring around the dredge and at the ocean side discharge point is being conducted by Florida Institute of Technology to meet standards set by FDEP to protect seagrasses on the flood shoal to the West of the inlet and nearshore hardbottom along the southern beaches. During dredge operations, a trained observer is required at all times to monitor for manatees and sawfish.

Sea turtle monitoring began on March 1 with Ecological Associates, Inc. (EAI) conducting daily nesting surveys at first light to clear beach crews to work, and any nighttime work is confined to a 500-foot work zone unless otherwise cleared by biologists from EAI. Post-project, scientists will monitor the beaches for the entire 2019 nesting season to ensure no impacts, including escarpments or changes in the profile of the beaches after grading. No Sebastian Inlet District projects have ever had a negative identified impact on sea turtle nesting on area beaches. EAI will also monitor for shorebirds per the FDEP permits, including the Piping Plover, after April 1 as needed.

“The Commission is committed to preserving natural resources and protecting important habitats and wildlife around the inlet as one of the most biodiverse regions in North America,” said James Gray, Sebastian Inlet District executive director who is replacing Smithson. “Every project is carefully designed and planned. The District and its contractors work with biologists, officials and regulatory agencies to conduct important environmental monitoring that takes place pre-, during and post-project. We have a track record of doing these projects in an environmentally responsible way and we take that seriously.”

Immediately after the project, marine biologists with CSA Ocean Sciences (CSA) who conducted a comprehensive, pre-project nearshore hardbottom survey this summer will go in to conduct a post-project survey to ensure no sand has migrated to cover the important nearshore hardbottom habitat South of the inlet. The last ten years of environmental monitoring shows no impacts from Sebastian Inlet District projects.

James Gray showing reporter Sue Cocking sand material

Once beach operations are completed, Ferreira Construction will begin dredging the 150-foot wide channel that connects Sebastian Inlet to the Intracoastal Waterway, stockpiling beach quality sand in the District’s DMMA, a 6-acre site located immediately Northwest of the Tidal Pool within Sebastian Inlet State Park. This site can be easily accessed for truck haul if area beaches are

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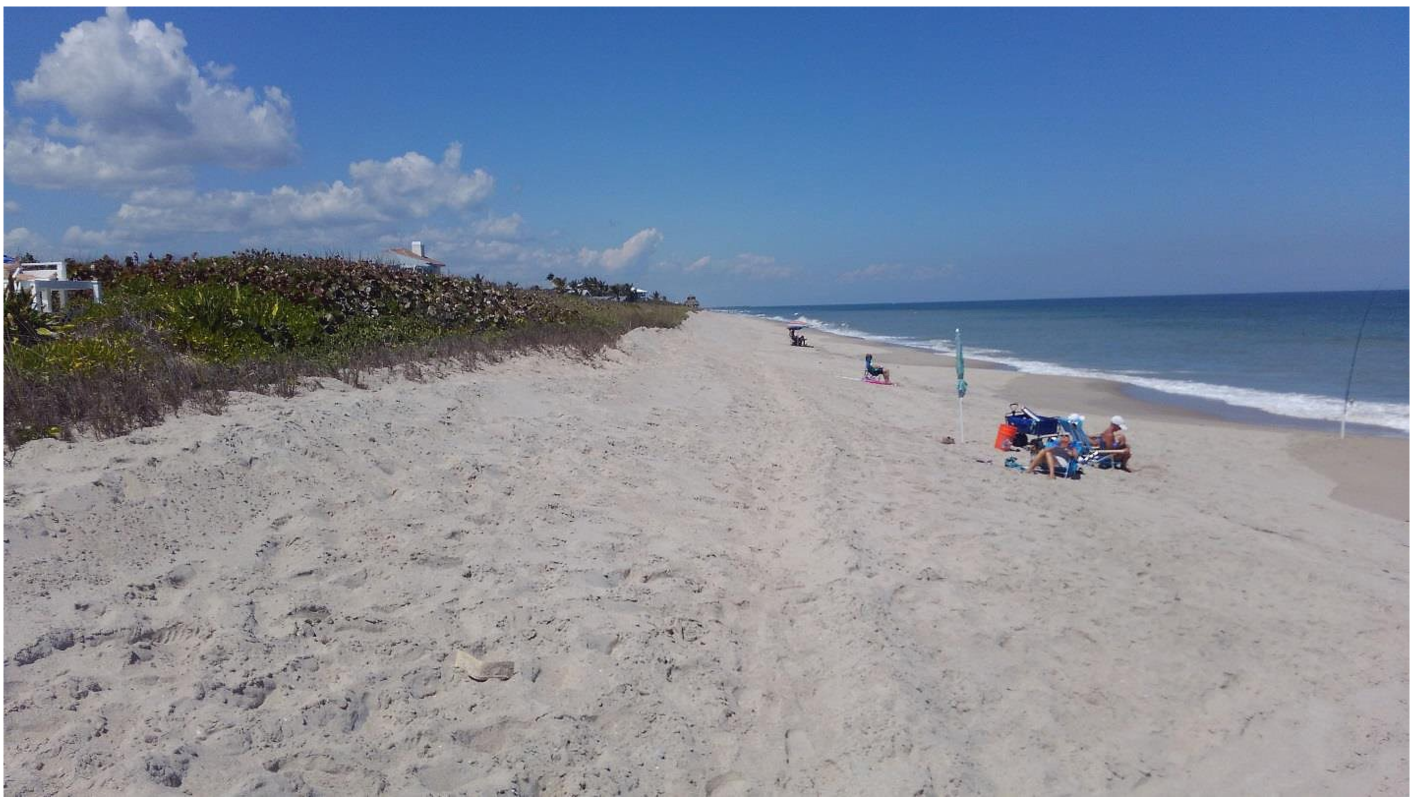
negatively impacted by hurricanes and other natural events. With some weather and equipment delays, this phase of the project is now expected to be completed by the end of May.

More than 2.5 million cubic yards of sand has been placed during beach restoration projects in the Sebastian Inlet District's almost 100-year history.

The Sebastian Inlet supports a rich and diverse ecological environment that is unparalleled in North America, and is located on the East coast of Florida between Brevard and Indian River counties. The inlet is vital not only to the ecological health of the Indian River Lagoon, but it is also an important economic engine for local communities in the region. Known as a premier fishing, boating, surfing and recreational area, the Sebastian Inlet is bordered on both sides by Sebastian Inlet State Park, one of the most visited parks in Florida. Sebastian Inlet is one of only five navigable channels that connect the Indian River Lagoon to the Atlantic Ocean.

The Sebastian Inlet District was created in 1919 as an independent special district by act of the Florida State Legislature and chartered to maintain the navigational channel between the Atlantic Ocean and the Indian River. Governed by a 5-member elected Commission, Sebastian Inlet District responsibilities include beach renourishment as part of a state-mandated bypass system, erosion control, environmental protection and public safety.

In May, the Sebastian Inlet District will be kicking off a year-long centennial celebration with an interactive social media campaign featuring historical photo archives and promotional give-a-aways, a family-friendly community event, an environmental education lecture series and more. Join in the fun at www.sitd.us or follow us on Facebook!



Ambersand looking North - finished beach profile

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Mobility of Unexploded Ordnance using Spherical Surrogates on the Beach Face

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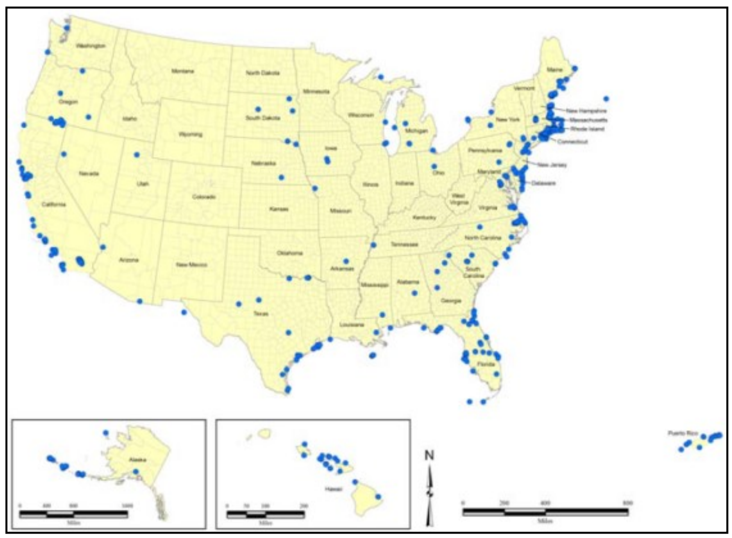

Figure 1: Formerly Used Defense Sites (SERDP, 2010)

Introduction

Prior military testing activities have led to the desertion of munitions (also referred to as unexploded ordnance; UXO) on Formerly Used Defense Sites (FUDS) and adjacent coastal environments. Identified munitions at such sites are either removed, left in place, or blown up, depending on public risk, effort, and cost, required for remediation. Many FUDS tend to be concentrated along the coast (Figure 1) and are subjected to a range of hydrodynamic forcing and morphodynamic variability. Data are lacking on how munitions mobilize and migrate, especially near the shoreline and in relation to varying coastal conditions. For instance, storms and subsequent beach evolution may exhume UXO and allow for cross-shore and/or alongshore UXO migration increasing risk to the public. Sites deemed munitions-free may still be at risk of being re-populated through migration processes. Dredging of contaminated offshore borrow sites for beach nourishment projects can also lead to the distribution of munitions on the foreshore.

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The Department of Defense supports the Strategic Environmental Research and Development Program (SERDP) with one thrust area being a Munitions Response program (Figure 2). A key aspect of this program is the creation of a model that site managers can use for risk assessment. Researchers at the Johns Hopkins Applied Physics Laboratory have developed the Underwater Munitions Expert System (UnMES), that is built on a probabilistic Bayesian framework (Rennie et al., 2017). UnMES requires both laboratory and field data for further development/refinement. The probabilistic nature of munitions response can be quantified during constant wave forcing in a laboratory setting. This paper focuses on the setup and preliminary analysis of a laboratory experiment designed to develop techniques for tracking and predicting munitions motion. The results from this study will ultimately be incorporated into UnMES for determining munitions behavior.

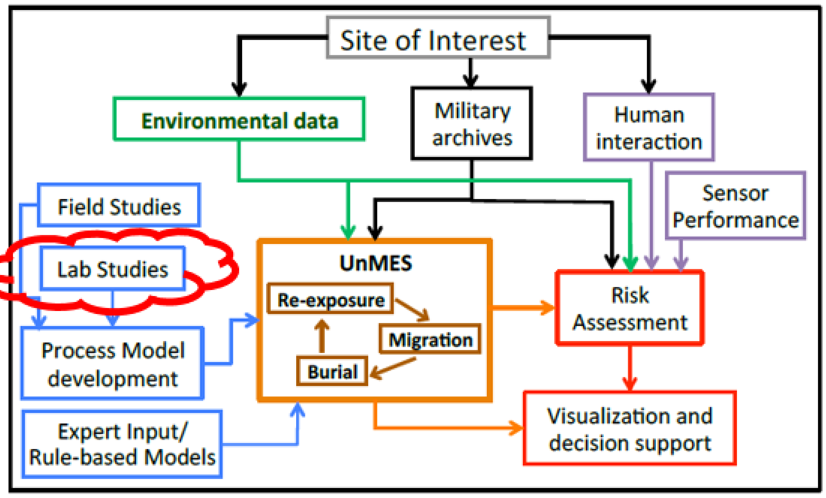

Figure 2: Work-flow of Munitions Response program created by SERDP to characterize risk and plan for remediation efforts (Rennie et al., 2017).

Experimental Setup

A laboratory experiment was conducted in a wave flume (Figure 3) at the Center for Applied Coastal Research (CACR) to quantify the mobility of BLU-61 (Figure 5) surrogate munitions. The portion of the flume used in the study is 9.4 m long with a 1:7 sloping mobile bed (median grain diameter = 0.31 mm) established over the last 4.8 m. A dam-break mechanism was used to create a solitary swash event (Figure 4). A gate was resisted by vertical stops along the flume wall and retained a reservoir of water (0.73 x 1.00 x 0.57 m^3). The gate was raised rapidly by releasing a 45 kg mass on a 2.64 m rod hinged to a pinned support. The retained fluid was released and propagated down the flume as a broken bore. The bore impinged the sloping bed and collapsed as swash.

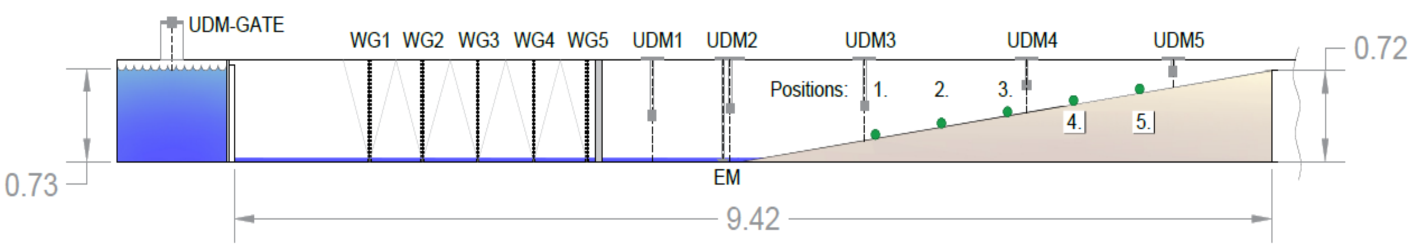

Figure 3: Scaled model of flume set-up and testing positions for the spherical surrogates. Dimensions in meters.

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Water level was recorded at 10 cross-shore locations using resistance wave gauges (WG) mounted on the flume wall and ultrasonic distance meters (UDM) mounted on carts (Figure 3). An electromagnetic current meter (EM) was used to determine velocity at the toe of the beach and at the locations where surrogate munitions were deployed. The sensor is positioned roughly 0.02 m above the bed. The small elevation above the bed means that the entire swash event cannot be captured; a problem that occurs with any current meter in a swash zone study (Chardón-Maldonado et al., 2016).

Figure 4: Snapshots of the dam-break mechanism upon initiation producing a swash event.

Munition size and density are two primary parameters believed to be important for mobility and burial (Rennie et al., 2017; Calantoni, 2017). For instance, objects with a specific gravity (SG) < 2 are thought to remain proud, while objects with a SG > 4 generally bury. Here, BLU-61 spherical surrogates of different SG but same dimensions (~0.08 m diameter) were constructed to quantify the importance of density to munitions response. Densities were altered using four different materials: concrete (SG = 1.8); aluminum (SG = 2.7); lead-core with a galvanized steel shell (SG = 4.2); and stainless steel (SG = 7.7). Note, the real BLU-61 has SG = 5.1. The four surrogate types were placed at five different cross-shore locations on the sandy bed and were buried at three different initially burial depths (~0%, 30% and 50% of total surface area) depending on the experimental run. Two surrogates could be tested concurrently afforded by adequate flume width for no interaction between them. Each scenario was repeated five times, producing 150 experimental tests Experimental scaling is avoided due to swash velocities of roughly 2 m/s, similar to what is observed in the field (Masselink and Puleo, 2006).

Figure 5: Single BLU61 Cluster Bomb.

A wide-angle field of view camera was deployed from overhead to capture the variations in sphere response based on the different initial conditions. A Velodyne laser system was used to monitor bed surface repeatability by calculating a root-mean-square error (RMSE) in elevation of a smoothed bed compared to an ideal profile. The beach was reset after each test and a RMSE of < 3 mm was maintained. Control on the initial morphology was necessary to reduce experimental perturbations and enabling capture of the probabilistic nature of surrogate response under repeated hydrodynamic forcing.

Hydrodynamic Analysis

Parameterization of the hydrodynamic forcing is crucial in determining thresholds for surrogate mobility (e.g. object mobility number for dimensional analysis; Rennie et al., 2017). Quantities such as object acceleration, drag, reduced gravity and bottom friction all depend on the surrogate submerged volume upon impact. Thus, free surface and velocity data at the instant of mobilization must be measured directly or interpolated to a given location from available data (Figure 4).

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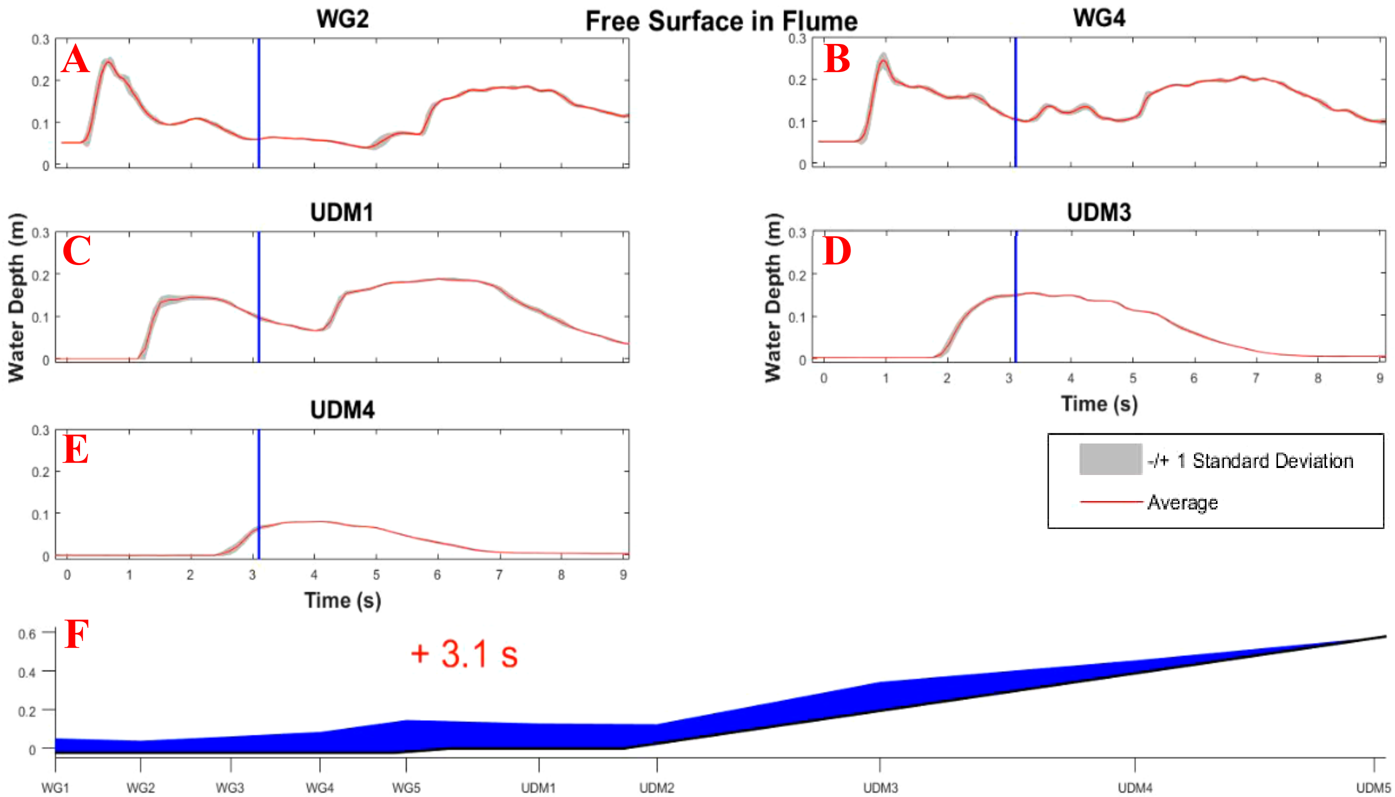

Figure 6: Determination of free surface from various sensors in the cross-shore. Linear interpolation between collected data allows for estimation of water depths at all locations.

Data obtained from two WGs (Figure 6A, B) and three UDMs (Figure 6C-E) show the mean bore propagation of 10 runs (red) down the flume. The data also reflect the repeatability of the generated swash with a standard deviation (grey shading) of only +/– 2 mm for most of the event. A reflected wave is only visible in Figures 6A-C, starting around 4 s for UDM1. A spatial snapshot of depth at a time of 3.1s (the vertical blue line in Figure 6A-E) is used to determine water depth throughout the flume (Figure 6F). UDMs were not deployed above the beach slope to not obstruct the field of view of the overhead camera. Therefore, free surface was measured without surrogates in the flume and interpolated for the time of impact at the deployed location of the surrogate. Interpolation methods beyond a linear fit (Figure 6F) will be implemented in the future for a more accurate estimate.

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Velocity measurements were recorded five times at each position and averaged to obtain a velocity time series (Figure 7). A second-degree polynomial fit was applied at each location assuming the dominant forces are friction and gravity. All fits resulted in an R^2 value greater than 0.99, and a RMSE < 0.06 m/s. A UDM was deployed alongside the EM, to determine when water is present. Velocity was then extrapolated to this instant, ~0.4 s before the EM sensor head is submerged.

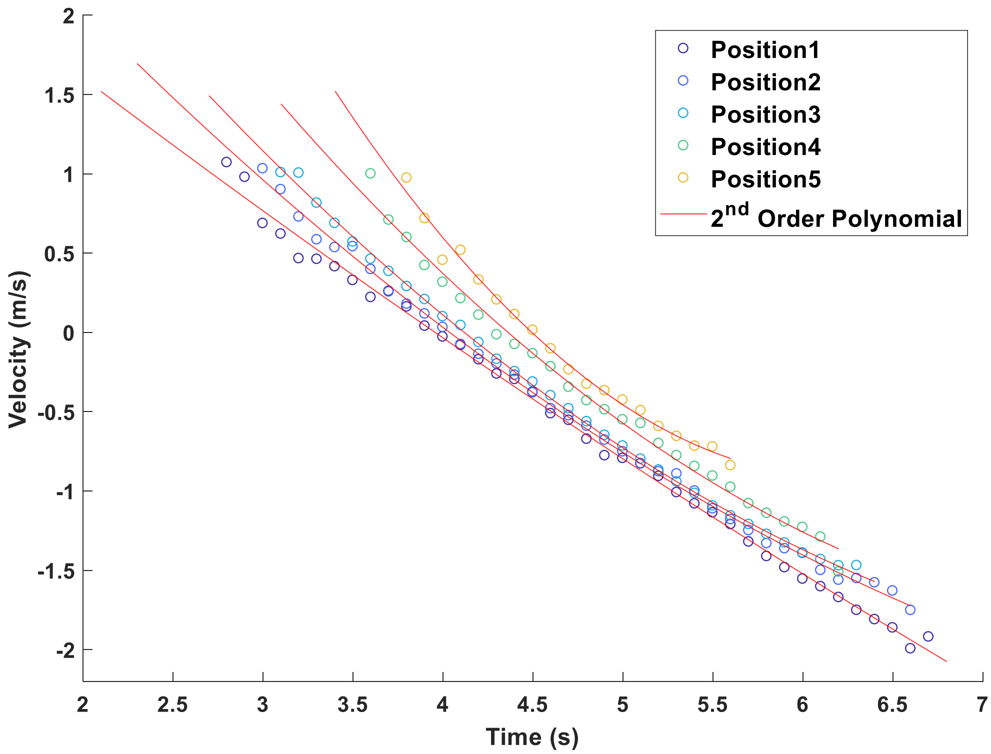

Figure 7: Mean velocity data (symbols) and 2nd order polynomial fits (solid curve) at five cross-shore positions (identified in Figure 4).

Initial velocities at all positions approached ~1.5 m/s, whereas different velocities were reached during backwash. Maximum backwash velocity is dependent on the amount of water accumulated landward of each position before flow reversal. Lower positions were subject to a longer build-up of fluid momentum, allowing gravity to have a longer influence. Offshore directed flows at Positions 1 – 3 approached values equal to or greater than those upon impact.

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Sphere Tracking

Cross-shore position of each sphere was identified using a motion-based object tracking technique. The spheres were painted green to easily identify them in each frame recorded by the overhead camera (Figure 9). The tracking entails applying a mask to each frame, which excludes all pixels not within the flume (Figure 9D, E) as well as all pixels that do not meet a certain threshold of intensity (Figure 9C). In this case, the 'green-most' pixels were selected, since the spherical surrogates were painted a contrasting color to that of the background.

Each raw image (Figure 8A) is first split into red-green-blue pixels (Figure 8B), and after choosing the most intense green pixels, a morphological enhancement is performed to select the two biggest clusters of pixels. The clusters are enhanced to be the only identifiable items in the image (Figure 8F). This series of modifications is applied throughout time to track the total sphere trajectory.

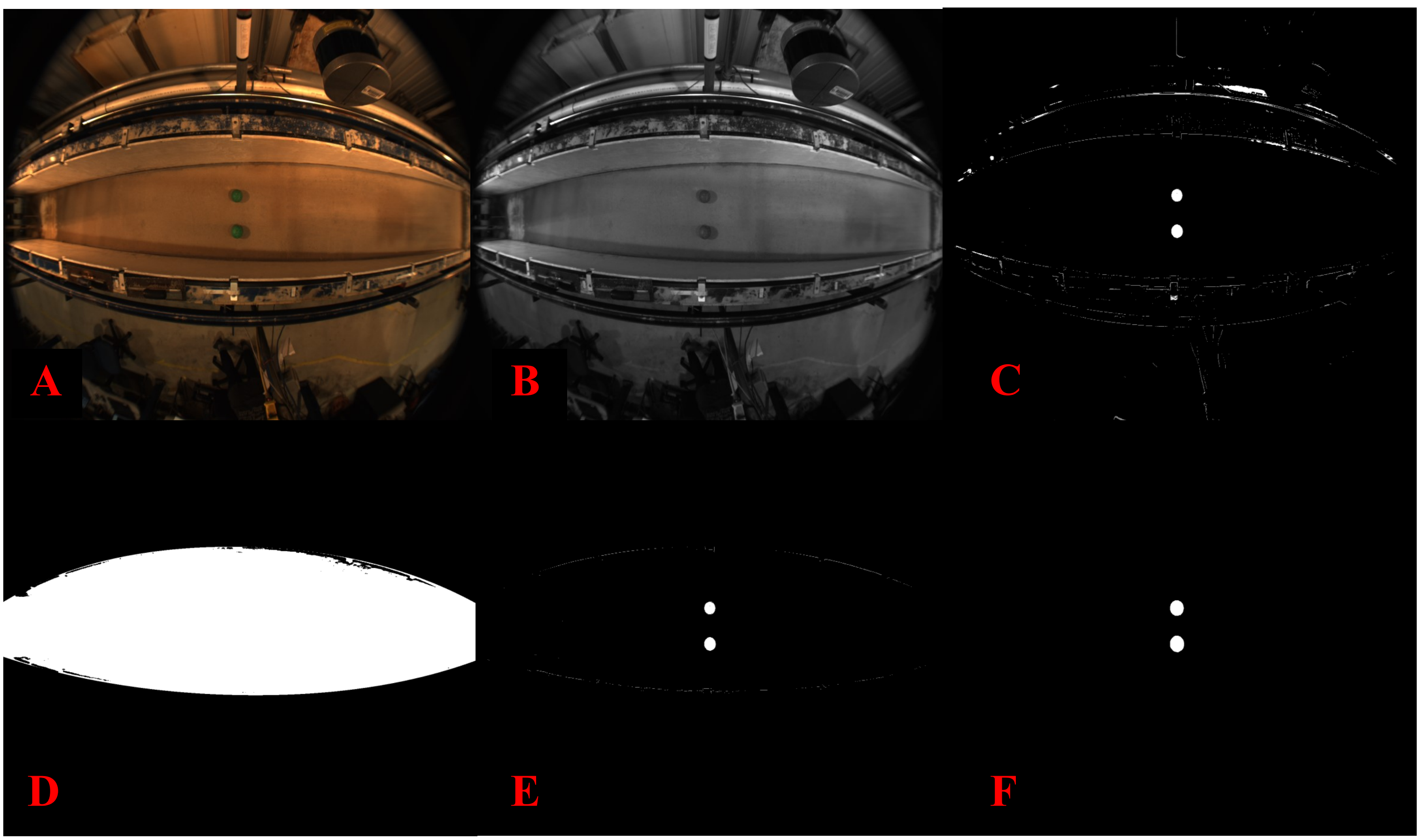

Figure 8: Series of image alterations used to identify only the two green spherical surrogates.

A cost assignment is applied after every detection to keep the spheres as separate objects (Figure 9A). The spheres are not identifiable in every frame, especially when first impacted by swash and when they are transported during backwash to the highly turbulent region at the toe of the beach. A Kalman filter is applied to predict the new location based on past detections (Figure 9B). The Computer Vision Toolbox in Matlab was used to apply these corrections and extract consistent time series of sphere tracks.

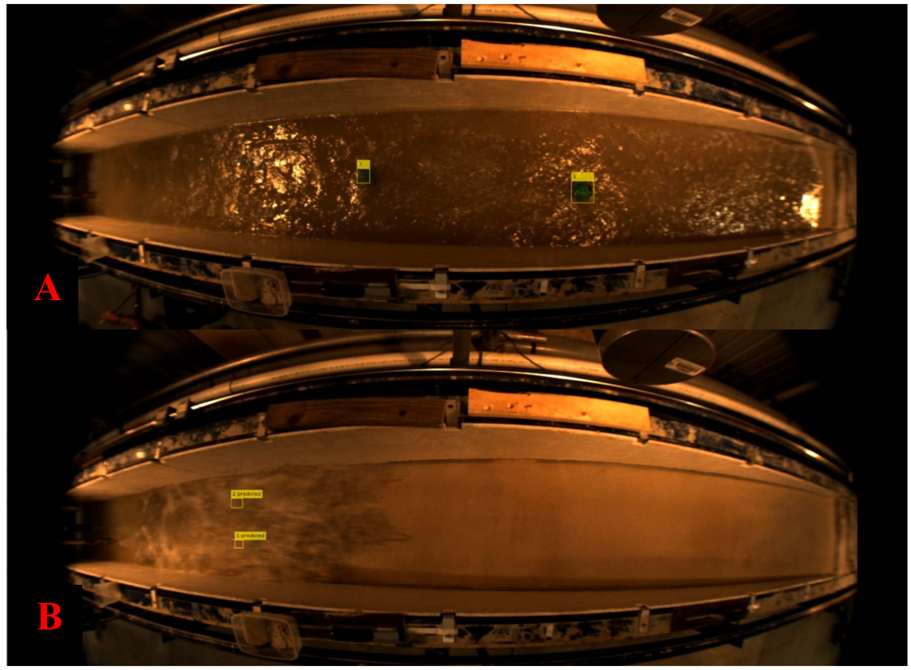

Figure 9: Detection of the spherical surrogates with mask alone (A) and with the assistance of a Kalman filter (B).

Trajectories at this stage are recorded in pixels. An image rectification was performed to translate pixel coordinates (UV) into real-world coordinates (XYZ). This technique, known as georectification, applies a non-linear regression algorithm to rectify an image based on internal camera parameters and geometric relations of image to ground coordinates (Holland et al., 1997).

Sphere Mobility

Important parameters to extract from the observed sphere response include: initiation of motion, duration of mobility, maximum runup and run-down, maximum onshore- and offshore-directed velocities, and initial burial depth versus final burial depth. Sphere trajectories can be visualized using different image processing techniques. One technique is known as a time stack (Aagaard and Holm, 1989) that is used to compare sphere trajectories with wave runup. Time stack construction entails plotting a georeferenced transect of pixels on the y-axis over the entire swash duration (Figure 10). Plotting pixels in this manner allows for a clear depiction of the incoming bore and subsequent backwash (Figure 10, solid purple line). Plotting the response of five repeated runs highlights both the variability in response due to perturbations in the experiment and the different trajectory characteristics due to density differences, with the lightest colors corresponding to the lightest spheres.

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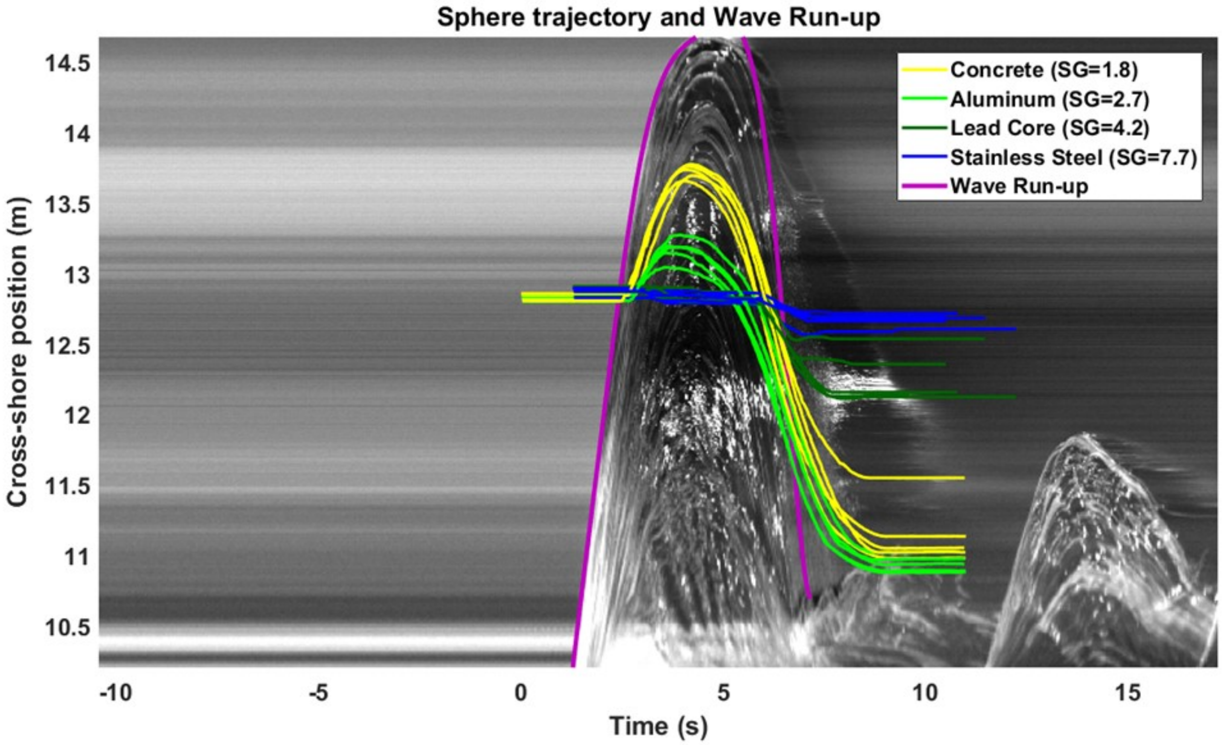

Figure 10: Sphere trajectories overlain on a runup time stack.

A prediction for mobility can be made with a certain level of confidence by averaging these five trajectories. Averaged trajectories (Figure 11) can then be compared for different initial conditions and thresholds of motion for density, burial and position can be estimated. A complete analysis of the aforementioned parameters is currently being conducted. Examples for differing densities and burial depths at a specific cross -shore location are discussed here. Less dense spheres (Figure 11A, B,) tend to mobilize upon initial impact, if not buried to 50% for the case of concrete and 30% for the aluminum sphere. For the more dense spheres (Figure 11C, D) initiation of motion does not occur until late in the backwash for all burial depths. The lead-core sphere then travels farther down slope since it is less resistant to the driving force of the backwash than the stainless steel sphere. The less dense spheres seem to extract similar momentum when placed proud, however, since they come to rest at similar offshore positions.

Offshore sphere motion occurs slightly before the runup edge reverses motion for cases when the when a sphere is mobilized on initial impact. This lag is due to the fact that local flow reversal does not coincide with the leading swash edge reversal. It is thus important to extract the local water velocity and depth to compare with the sphere velocity and initiation of motion. The associated water depth and velocity will be extracted from the data record using the identified time of sphere mobilization. These values will then be used in the construction of the object mobility number.

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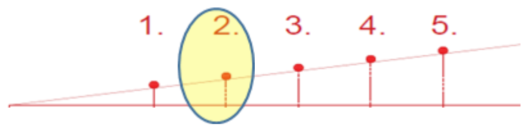

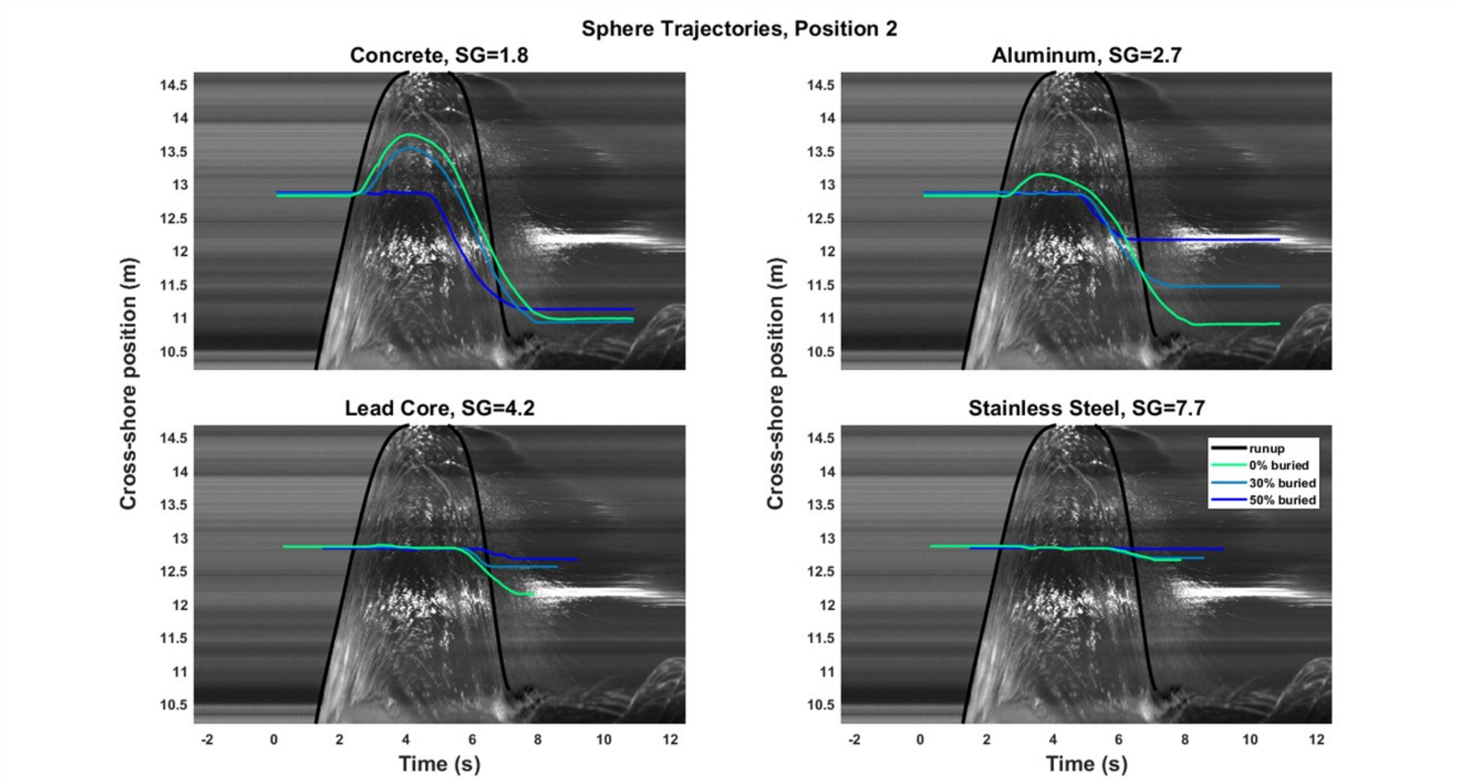

Conclusions

A laboratory study was conducted to identify the response of spherical surrogates under constant wave forcing. Different responses were identified when changing the initial conditions of the experiment. There is a critical burial depth that will alter the behavior of the two less dense spheres. There is also a critical density where surrogate response will change from mobilizing on impact versus only during backwash. Both of these thresholds lie between the scenarios tested in this experiment, and thus need to be estimated through interpolation once all results have been tabulated. A similar analysis will be performed in determining the critical cross-shore position for a specific surrogate density that will prohibit significant mobility.

Detailed measurements of the morphology, hydrodynamics and surrogate response were recorded throughout testing. Characterization of the incoming wave and the surrogate response is especially important when building a probabilistic model for the monitoring and extraction of UXO on Formerly Used Defense Sites. Further analysis of the collected data is necessary to contribute to and refine previous parametrized equations (Rennie et al., 2017). Personnel at the CACR are conducting other experiments including field studies and deploying surrogates with internal sensors to track motion (Bruder et al., 2018). These efforts will help site managers determine the level of risk associated with each site and the appropriate steps for management.

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USACE Jacksonville District

FEDERAL PROJECT STATUS UPDATES – April 2019

By Gabriel Todaro, Intern, EN-WC, USACE Jacksonville District

US Army Corps of Engineers®

PLANNING STUDIES:

- **South Atlantic Coastal Study**

The South Atlantic Coastal Study (SACS) is a study authorized by the Water Resources Development Act (WRDA) 2016. This study will identify coastal risk and vulnerabilities due hurricane and storm damage as a result of sea level rise in regions from North Carolina to Mississippi. This study is expected to take 3 years to complete and is expected to identify the reconnaissance-level analysis of coastal risk and vulnerability as well as potential solutions to be studied in greater detail in the future.

- **Broward County Shore Protection Project - Segment III**

Broward County submitted a letter of interest in March 2016 to request extension of the Federal project an additional 15 years. Broward County is under procurement to obtain a contractor to initiate the LRR for Segment III. Funding for this project has not been yet been obtained.

- **Ft. Pierce Shore Protection Project**

The last renourishment was completed in June 2018. Work for the next and final renourishment needed prior to the expiration of federal participation in November 2020 will commence in 2019. This is dependent on obtaining funds in the Fiscal Year 2020 workplan. A General Re-evaluation Report (GRR) was completed by St. Lucie County and sent to congress. Approval of this GRR would extend federal participation for another 50 years.

- **Lee County – Gasparilla Island**

A Section 934 report has been initiated to determine the Federal interest in extension of Federal participation in cost-sharing from the current 10 years to a 50-year period of Federal participation, or an additional 40 years. The Tentatively Selected Plan (TSP) Milestone Meeting was held on October 17, 2016. The draft report was released for agency and public comment and an Agency Decision Milestone (ADM) meeting was held in February 2017. The final report was submitted to South Atlantic Division in May 2017. ASA (CW) approval is scheduled for June 2018 approval.

Supplemental funding was received for the renourishment of the project area. Permits are being obtained for the project.

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ENGINEERING AND DESIGN:

- **Broward County Shore Protection Project - Segment II**

The PIR for Hurricane Irma for Broward County Segment II has been approved for renourishment of the beach. The project is expected to renourish about 388,000 cubic yards of sand. The contract for the project was expected to be awarded in late 2019 but recent surveys have shown heavy erosion in unpermitted areas. In order to include these areas, a new permit modification will be needed. This is expected to add a year to the schedule.

- **Dade County Renourishment**

There are 4 separate contracts being prepared over the next 3 years. Contract A will cover a truck haul project to Surfside Beach. This contract is expected to be awarded in May 2019. Contract B is a truck haul to Miami Beach Hot Spots with an award date in June 2019. Contract C is the renourishment of Bal Harbour. This project is expected to be awarded in March 2020. Contract D will cover Sunny Isles and the remaining portion of Miami Beach. This contract is expected to be awarded in summer 2020.

- **Flagler County Shore Protection Project**

The design of the plans and specifications for the Flagler County Shore Protection Project are being development. The contract is expected to be advertised in 2020.

- **Manatee County Shore Protection Project**

The Project Delivery Team (PDT) is working on the plans and specifications. Award of the contract is anticipated to occur in early 2020.

- **Sarasota County - Lido Key**

SAJ is currently working with the sponsor to execute the Project Partnership Agreement by 30 September 2018. Plans and Specifications are set to begin mid-October 2018 with award scheduled for June 2019.

- **St. Lucie Coastal Storm Risk Management – South Segment**

This is a new project that will be funded with funds from the supplemental bill. Plans and specifications were started in September 2018 however St. Lucie County has requested the project to be pushed back by 2 years due to concerns with real estate and the need to obtain the required non-federal funding. Advertisement for this contract is expected to occur in late 2021 with construction occurring in 2022.

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CONSTRUCTION:

- **Brevard County South Reach**

Brevard County South Reach has been approved for $9,000,000 in Supplemental funding for additional quantities to the design template. The award is scheduled for the 4th quarter of fiscal year 2019 and it will be included as part of the Mid Reach Initial fill contract.

- **Brevard County Mid Reach**

Construction of the mitigation feature (reef mats) is expected to be complete in July 2019. The initial fill for the project will be combined with the South Reach construction. Construction award will occur in the 4th quarter of fiscal year 2019.

- **Broward County Shore Protection Project - Segment III**

Contract A was awarded 6 December 2018 to Eastman Aggregates for $7,900,000. Construction for this contract was started on 7 February 2019 and is expected to be complete in late April 2019. Contract B is scheduled to be awarded in fiscal year 2020.

- **Duval County Shore Protection Project**

The Construction of the Duval County Shore Protection Project was completed on 30 January 2019. The project placed approximately 850,000 cubic yards of sand on 8 miles of eroded beaches, including Jacksonville, Neptune, Atlantic beaches, and the southern Mile of Kathryn Abbey Hanna Park.

- **Nassau County Shore Protection Project**

Beach placement for the Nassau County Shore Protection Project is now complete. This project was done in combination with the dredging of the Kings Bay entrance channel. About 340,000 cubic yards of sand was placed on Fernandina Beach during the construction.

- **Pinellas County**

Sand Key: Construction by Norfolk Dredging Company was completed in October 2018.

Long Key: Contract Option D was exercised which will allow Norfolk to return in spring of 2019. This action is expected to add approximately 150,000 cubic yards of material.

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FDEP Agency Updates

From the Division of Water Resource Management

Beaches Funding Update

The FY 2019-2020 Local Government Funding Request (LGFR) and the 10-year Long Range Budget Plan (LRBP) were submitted to Governor DeSantis and the Florida Legislature on February 4, 2019. The requested state funding in the LGFR is $68.6 million for beach projects and $6.9 million for inlet management. The 10-year LRBP summarizes projected funding needs for the first five years beginning in FY 2019 and proposed project phases for the subsequent five years ending in FY 2029. The LGFR and LRBP can be found on the DEP website at https://floridadep.gov/water/beaches-funding-program/content/beaches-funding-documents.

Preliminary Hurricane Michael Storm Recovery Plan for Florida's Beach and Dune System

The Department developed the Preliminary Hurricane Michael Storm Recovery Plan to address short and long-term beach recovery costs for eroded beach and dune systems in Bay, Gulf and Franklin counties. The plan summarizes proposed management strategies and costs that incorporate ongoing federal, state and local efforts. The recovery of the beach and dune system is vital for providing essential environmental habitat for threatened and endangered species, and protection of upland development and infrastructure that are vital to the health, safety and economic welfare of the State of Florida.

DEP staff corresponded with federal, state and local agencies involved with storm recovery activities. Cost estimates were developed with the assistance of local sponsors and through supporting documentation provided by engineering consultants.

Projects include restoration of Mexico Beach, nourishment of Panama City Beach, St. Andrews State Park, St. Joseph Peninsula (with extensions), and dune restoration at Beacon Hilll/Windmark, St. George Island (several locations) and Alligator Point.

Please see https://floridadep.gov/water/water/content/dwrm-current-season-hurricanes-and-tropical-storms for details.

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Beaches, Inlets and Ports Program Reorganizes, Grows

The Beaches, Inlets and Ports Program is developing a more comprehensive compliance section and has added a new position to assist in tracking pre-construction items and permit required monitoring reports, as well as assisting with other compliance assurance and enforcement tasks. Martin Seeling retired and Ivana Kenny-Carmola has been promoted to Environmental Manager supervising the BIP Permit Managers. Recruitment is underway for another Environmental Specialist permit manager.

The Resource Review Section is also recruiting an Environmental Consultant to assist in the resource review of beach and port projects.

Justin Lashley has joined the Strategic Planning and Coordination Section. He will be assisting in revisions to the Strategic Beach Management Plan and in coordination with the Corps new Coastal Storm Risk Management studies, as well as general geotechnical and engineering coordination. Justin will also be assisting in permit management where needed.

BIPP has been working closely with the Corps on all emergency and supplemental projects. Monthly leadership review sessions are held, and bi-weekly meetings are held with staff to assure permits and permit modifications are issued before the Corps deadlines.

BIPP is also meeting with the FFWCC staff to assure the wildlife permit conditions are provided to the Department in a timely manner, and that all staff are up to date on breeding seasons, revised conditions and plans for new/revised permits. FFWCC staff now participate in the bi-weekly meetings, and monthly conference calls are scheduled to assure coordination.

See the updated web page at https://floridadep.gov/water/beaches-inlets-ports.

Florida Resilient Coastlines Program

Resilience is the ability to recover quickly from disasters and plan for and to adapt to future conditions such as sea level rise. The Florida Resilient Coastlines Program (FRCP) is DEP's effort to synergize community resilience planning, natural resource protection tools, and funding to prepare Florida's coastline for the effects of climate change, especially rising sea levels.

DEP's vision is that Florida's coastal communities are resilient and prepared for the effects of rising sea levels, including coastal flooding, erosion and ecosystem changes. FRCP reaches out to local communities with technical and financial assistance, and coordination to achieve this vision.

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Technical assistance includes in-person training on decision support tools such as those found on NOAA's Digital Coast website. Financial assistance is offered in the form of grants to help coastal communities perform vulnerability assessments, create adaptation strategies, and implement those strategies. Coordination via the Coastal Resilience Forum quarterly webinar provides opportunities for local, state, and federal agencies to interact with each other and with universities and nonprofits to share best practices and project ideas and outcomes.

If you would like to receive registration information for the Coastal Resilience Forum webinar, please email the FRCP Program Assistant, Faith Clarke at Faith.Clarke@FloridaDEP.gov. The next webinar date is May 8, 2019.

To find out more about this program in the Office of Resilience and Coastal Protection, check out the FRCP webpages https://floridadep.gov/resilience or contact Whitney Gray at (850) 245-2098.

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Shoreline

A monthly electronic publication of the Florida Shore & Beach Preservation Association.

CALENDAR OF EVENTS

FSBPA Conferences

September 18-20, 2019
62nd Annual Conference
Hutchinson Shores Resort
Hutchinson Island, Florida

Other Dates of Interest

May 27-31, 2019
Coastal Sediments 2019
Tampa/St. Pete, Florida

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