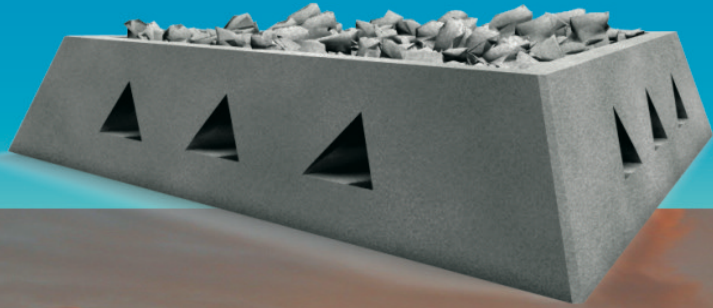


# Living Shoreline Solutions, Inc.

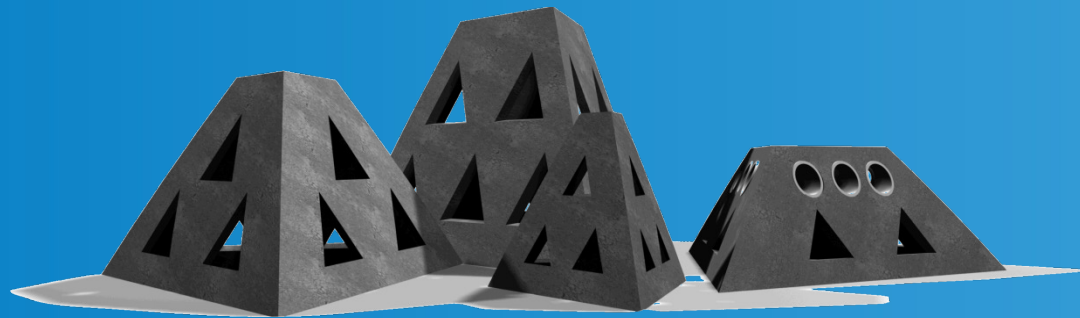


## *Coastal Restoration and Mitigation* *Total Beach & Shoreline Management System*



Living Shoreline Solutions Inc. brings 24 years of Research & Development, Peer Reviewed, Fully Patented Technologies with Proven, Project success rates that are unprecedented in the Field. To date, that Project Success Rate Remains 100%

WAD® (Wave Attenuation Device)



U.S. Patent 6,186,702B1

*Living Shorelines Solutions, Inc.*

DADE CITY, FLORIDA



# Scientifically Designed and Engineered Barrier Reef System.

## Dynamic, Complex, Marine Life Habitat



Durable, Stable and highly productive Essential Fish Habitat (EFH).

Measured, .47 Metric tons of Biomass Production per Square Meter surface area, annually. (Rodney Garner, Executive Summary on Fish Haven Productivity (GCMarSt) Queensland Australia

Site-Specifically Modeled and Engineered to Protect & Restore Coastal Zones and promote Productive Oyster Growth.



Portable and Adjustable for Dynamic Beach Rebuilding.

Minimal impact on live bottom due to hollow design and small foot print.

*Living Shorelines Solutions, Inc.*

DADE CITY, FLORIDA



# Wave Attenuation Device Applications (WAD®)

- Protective and Productive Barrier Reef Systems
- Productive Oyster Habitat (37% More)
- Sea Grass & Mangrove Restoration
- Essential Fish Habitat (EFH)
- Natural Shoreline Restoration
- On Shore Sand Dune Restoration
- Near Shore, On Shore Infrastructure Protection  
For roadways, bridges, critical transportation infrastructure.

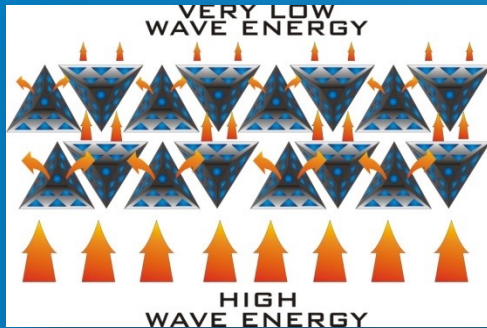


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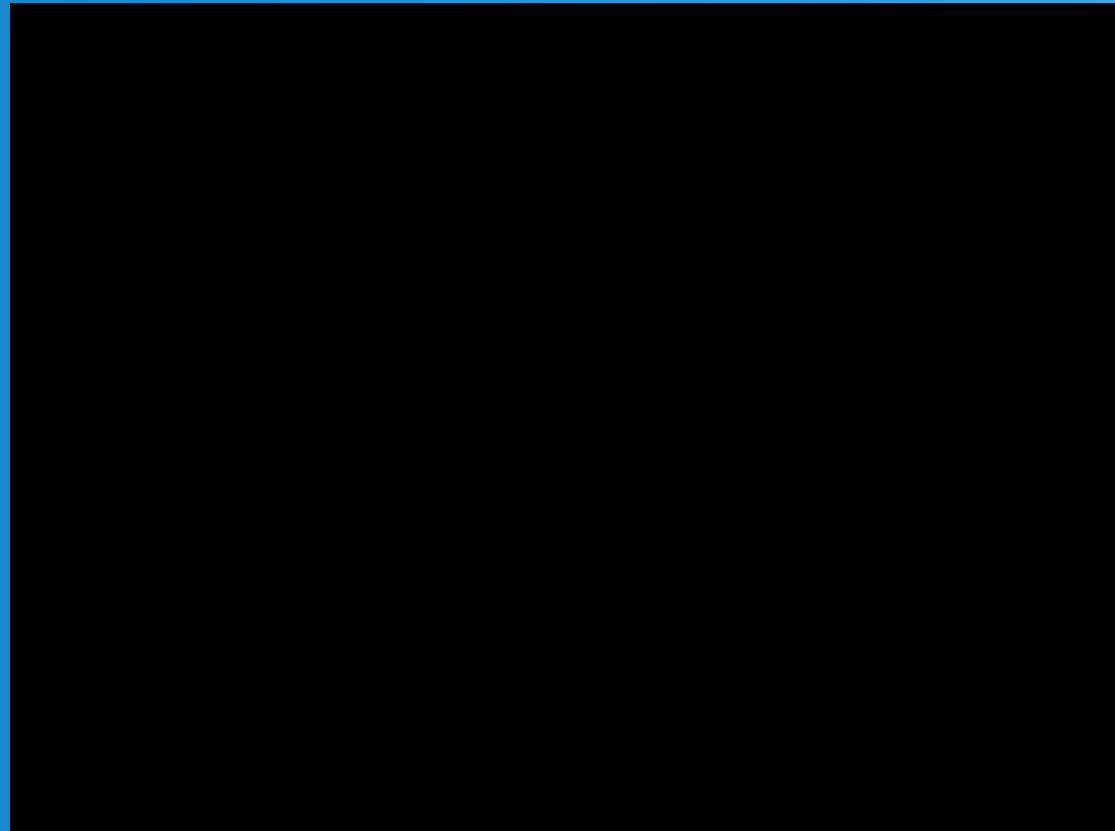


# Wave Attenuation Devices act as a Highly Efficient Breakwater



Observe the waves as they move through WADs and die out 3 feet behind WAD array.

- Attenuate wave energy. WADs do NOT reflect wave energy.
- Energy dissipated as wave encounters angled WAD sides.
- Openings on face are tapered inwardly (V/P) Increase/Decrease
- Openings back 2 sides (2X with (V/P) Decrease/Increase greater
- Causing suspended sediment to fall out of water column.
- **Depositing sediment shoreward of WAD array.**

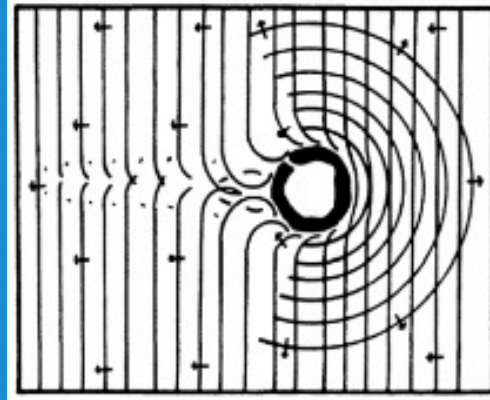
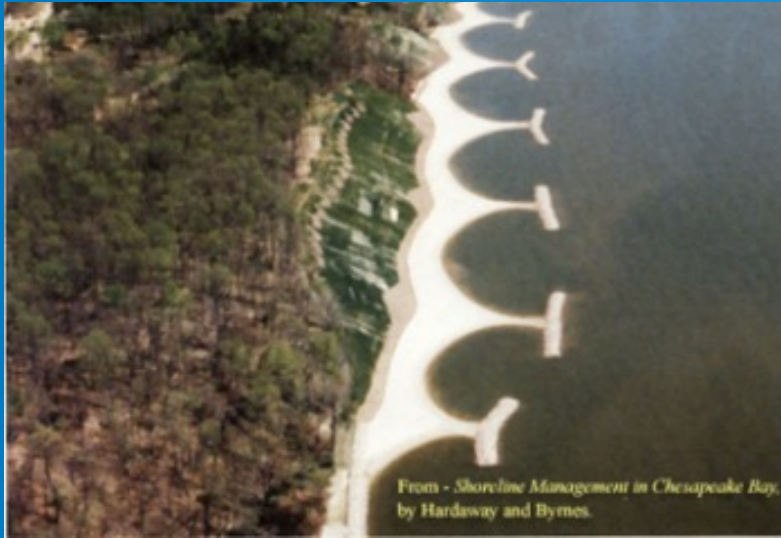


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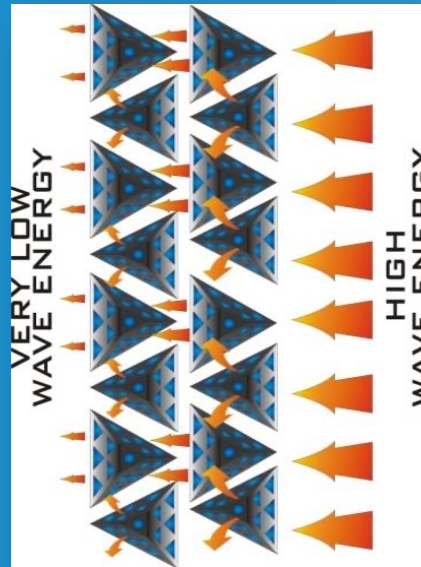


# Conventional Breakwater



- Deflect wave energy by refraction and reflection causing scouring behind artificially renourished beach behind breakwaters.

# WAD Array



- Direct wave energy attenuation through WAD array
- Notice accretion to the WADs. GAPS were clients' request. Continuous array is desired for full accretion profile.
- Energy attenuation supports sediment management and promotion of stable shoreline

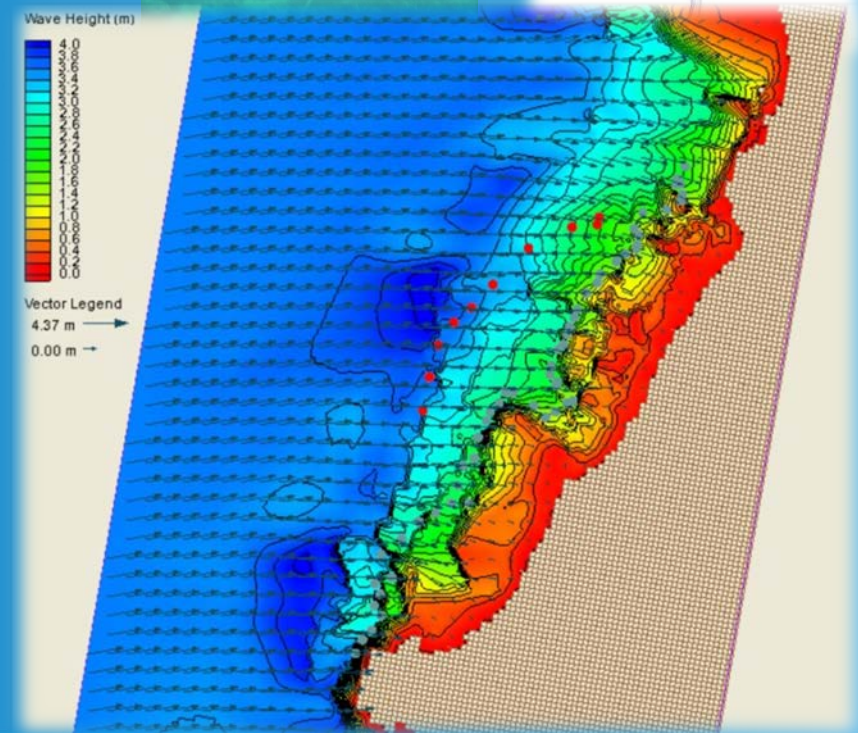
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Where do we start? Process is TURN-KEY, starting with a site visit and survey to determine the feasibility of designing a site-specific system, completing the following tasks:

- CLIENTS DESIRES
  - Hydrographic Survey
  - Coral Surveys
  - Current conditions
  - Geotechnical analysis
  - Wind-Wave analysis
  - Seasonal analysis
- 
- CMS Wave Model for wave attenuation: **OPTIONS PRESENTED FOR CLIENTS**  
**Priorities AND Budget**



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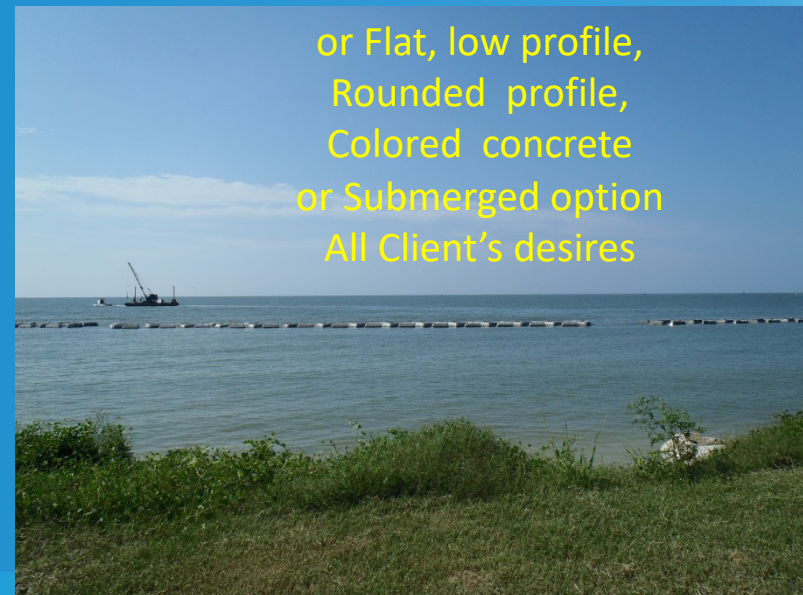
At permit award, steel WAD forms are manufactured and shipped to local manufacturing yard where local labor and materials will be used.



Local assets will then be used to transport and deploy WADs in designed WAD arrays.



WAD Profiles:  
Traditional Rock



or Flat, low profile,  
Rounded profile,  
Colored concrete  
or Submerged option  
All Client's desires

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# Audubon's Sunken Island Bird Sanctuary



- 75 year old man-made island
- Loss of breeding/nesting bird habitat
- Very unstable and subject to critical erosion

AERIAL OBTAINED FROM: FLORIDA AERIAL PHOTOGRAPHY ARCHIVE COLLECTION (APAC)  
 DATE OF PHOTOGRAPHY: OCTOBER 2008  
 THE STATE PLAN COORDINATE SYSTEM SHOWN IS BASED ON THE TRANSVERSE MERCATOR PROJECTION FOR THE WEST ZONE OF FLORIDA.

**LMA**  
 Landon, Moree & Associates, Inc.  
 Civil & Environmental Engineers - Planners - Surveyors  
 31022 U.S. 19 NORTH PALM HARBOR, FLORIDA 34694  
 Phone: (727)789-0010, Fax: (727)787-4294  
 Toll Free: 1-800-262-7963, WWW.LMAENR.COM

**AERIAL BASEMAP**

PROJECT:  
**SUNKEN ISLAND - WAVE ACTION DEFLECTION SYSTEM (WADS)**

PREPARED FOR:  
**AUDUBON OF FLORIDA**

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REVISIONS

**DRAFT**

SCALE:	1"=600'
JOB:	000-16,574
DATE:	03-01-2011
S H E E T	<b>02</b>
	OF <b>08</b>

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# LSS surveyed and modeled site conditions to design initial, 8 WAD array system with WADs 10 foot base, 5 feet tall, weighing ~8,100 lbs. each.

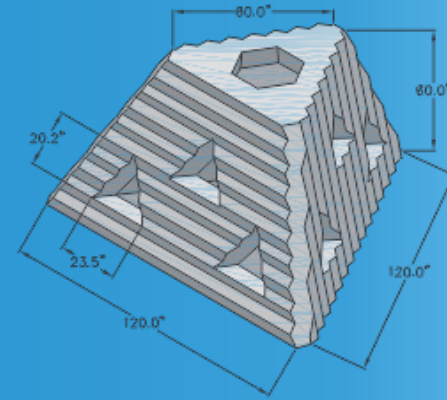
## GENERAL CONSTRUCTION NOTES

- All elevations refer to the North American Vertical Datum (1988).
- Horizontal coordinates are referenced to Florida State Plane, West Zone North American Datum of 1983 (NAD 83).
- The Contractor shall make their own determination of the quantities of work required to complete the construction shown on the plans. The Contractor shall also make their own assessment of the site and the port required prior to bidding and any discrepancies, errors or omissions shall be brought to the attention of the County representative before the bid due date.
- The Contractor is responsible for verifying the location of all underground utilities or other objects prior to commencing work on the site. Any utilities or other items damaged during construction shall be repaired at no cost to the Audubon Society of Florida or Nassau.
- All areas or items outside the limits of construction that are damaged or disturbed by the contractor shall be restored to their original or better condition at no cost to the Audubon Society of Florida or Nassau.
- The Contractor shall check plans for conflicts and discrepancies prior to construction. The Contractor shall notify the engineer of record of any conflicts before performing any work in the affected area.
- It is the Contractor's responsibility to become familiar with the permit and inspection requirements of the various governmental agencies. The Contractor shall obtain all necessary permits prior to construction and schedule inspections according to agency instruction.
- All specifications and documents referred to shall be of latest revisions and/or latest edition unless otherwise noted.
- All work performed shall comply with the regulations and ordinances of the various governmental agencies having jurisdiction over the work.
- Repair and replacement of all private and public property affected by this work shall be restored to a condition of equal to or better than existing conditions unless specifically exempted by the plans.
- All disturbed areas with the project not designated for improvements are to be restored to original condition or better.
- Record drawings: The Contractor shall be responsible for having a registered land surveyor to record information on a set of the approved plans concurrently with construction progress. One (1) set of the final record drawings shall be submitted to the engineer. Record drawings shall comply with the requirements in the Contract Agreement.
- WADs construction under this Contract shall include procurement, transportation, and placement of pre-cast concrete materials described herein and shown on the Contract Drawings. Work consists of furnishing of labor, material, equipment, and incidentals necessary for performing the work specified by the Contract. All work shall be in accordance with the Plans, Specifications and requirements set forth within the Contract and Project permits. All work to be conducted in accordance with all federal, state and local permits and authorizations issued for this Project.
- Site preparation: The contractor shall not disturb the existing seabed. The WADs shall be carefully placed on the existing seabed surface.

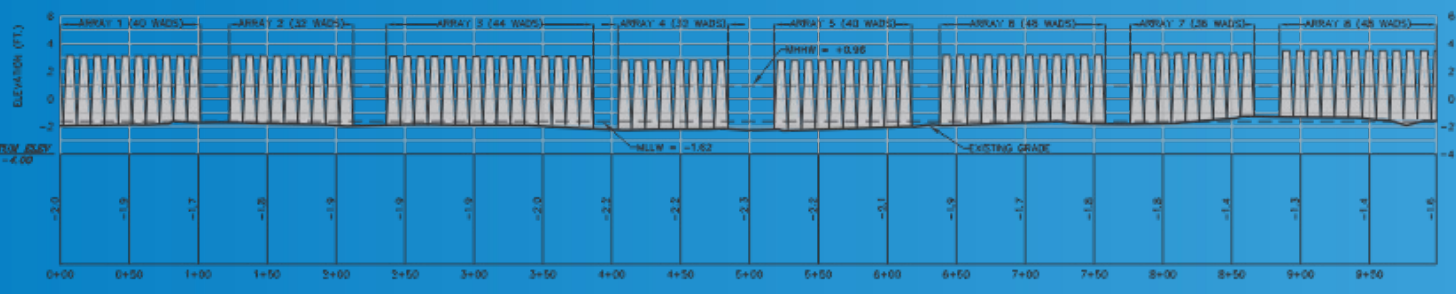
## STANDARD MARINE CONSTRUCTION CONDITIONS

The Contractor shall comply with the following monatee protection construction conditions:

- The Contractor shall instruct all personnel associated with the project of the potential presence of monatees and the need to avoid collisions with monatees. All construction personnel are responsible for observing water-related activities for the presence of monatees.
- The Contractor shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing monatees which are protected under the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and the Florida Monatee Sanctuary Act.
- Station barriers shall be made of material in which monatees cannot become entangled, are properly secured, and are regularly monitored to avoid monatee entanglement. Barriers must not block monatee entry to or exit from essential habitats.
- All vessels associated with the construction project shall operate at the "wakeless" speeds of all times while in the construction area and while in water where the draft of the vessel exceeds more than a four foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.
- If monatee(s) are seen within 100 yards of the active daily construction/dredging operation or vessel movement, all appropriate precautions shall be implemented to ensure protection of the monatee. These precautions shall include the operation of all moving equipment no closer than 50 feet of a monatee. Operation of any equipment closer than 50 feet to a monatee shall necessitate immediate shutdown of that equipment. Activities will not resume until the monatee(s) has departed the project area of 1/2 mile radius.
- Any collision with one/or injury to a monatee should be reported immediately to the FWC hotline at 1-888-404-FWCC. Collision and/or injury should also be reported to the U.S. Fish and Wildlife Service in Jacksonville (1-904-232-2560) for North Florida or Vero Beach (1-772-562-2009) in South Florida.
- Temporary signs concerning monatees shall be posted prior to and during all construction/dredging activities. All signs are to be removed by the Contractor upon completion of the project. A sign measuring at least 2' H by 4' W, which reads "Caution: Monatee Habitat" are to be posted in a location prominently visible by water related construction crews. A second sign should be posted if vessels are associated with the construction, and should be placed visible to the vessel operator. The second sign should be at least 8-1/2" by 11" which reads "Caution: Monatee Habitat" and speed is required if operating a vessel in the construction area. All equipment must be shutdown if a monatee comes within 50 feet of operation. Any collision with one/or injury to a monatee shall be reported immediately to the FWC hotline at 1-888-404-FWCC. The U.S. Fish and Wildlife Service should also be contacted in Jacksonville (1-904-232-2560) for North Florida or Vero Beach (1-772-562-2009) in South Florida.



WWW.LIVINGSHORELINESOLUTIONS.COM  
**WAVE ACTION DEFLECTION SYSTEM (WADS)**  
 N.T.S.



**WADS ALIGNMENT**  
 SCALE: 1" = 8' VERTICAL, 1" = 80' HORIZONTAL

**TIDAL DATA**

MHHW	= +0.96
MHW	= +0.74
MSL	= -0.19
MLW	= -1.24
MLLW	= -1.62

**LMA**  
 London, Morse & Associates, Inc.  
 Civil & Environmental Engineers - Planners - Surveyors  
 31422 U.S. 15 NORTH PALM HARBOR, FLORIDA 34684  
 Phone: (772)82-5011 Fax: (772)81-4394  
 Toll Free: 1-800-202-7995 WWW.LMAINC.COM

**CONSTRUCTION NOTES & PROFILE VIEW**

PROJECT:  
**SUNKEN ISLAND - WAVE ACTION DEFLECTION SYSTEM (WADS)**

PREPARED FOR:  
**AUDUBON OF FLORIDA**

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REVISIONS


**DRAFT**

SCALE: 1"=80'

JOB: 000-15.074  
 DATE: 03-01-2011

S  
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**07**

OF **08**



WAD unit manufacturing at local marina, nearest deployment site



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Using local assets to move and place WADs in shallow water application  
at Sunken Island.



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First two of 8, WAD arrays in place. (Observe improved WAD design with horizontal corrugation on front face of WAD and vertical corrugation on back two sides to further attenuate wave energy.)



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## Restoration sites and storms no longer have an adverse relationship

April 27, 2012 at high tide,  
6 months following WAD  
deployment (late 2011)

Marine life access with segmented or overlapping gaps  
Turtle nesting , manatees etc.

Sunken Island Tampa Bay, FL

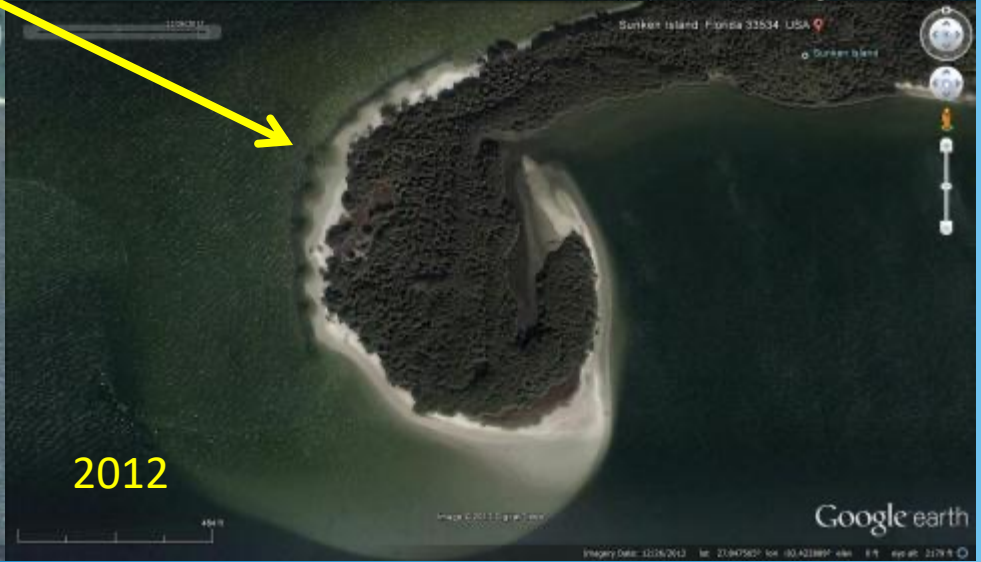
June/July 2012 (9 mo. post installation)  
near high tide, shortly after Tropical Storm  
Debby (65 mph winds &  $\pm$  10 in. of rain)



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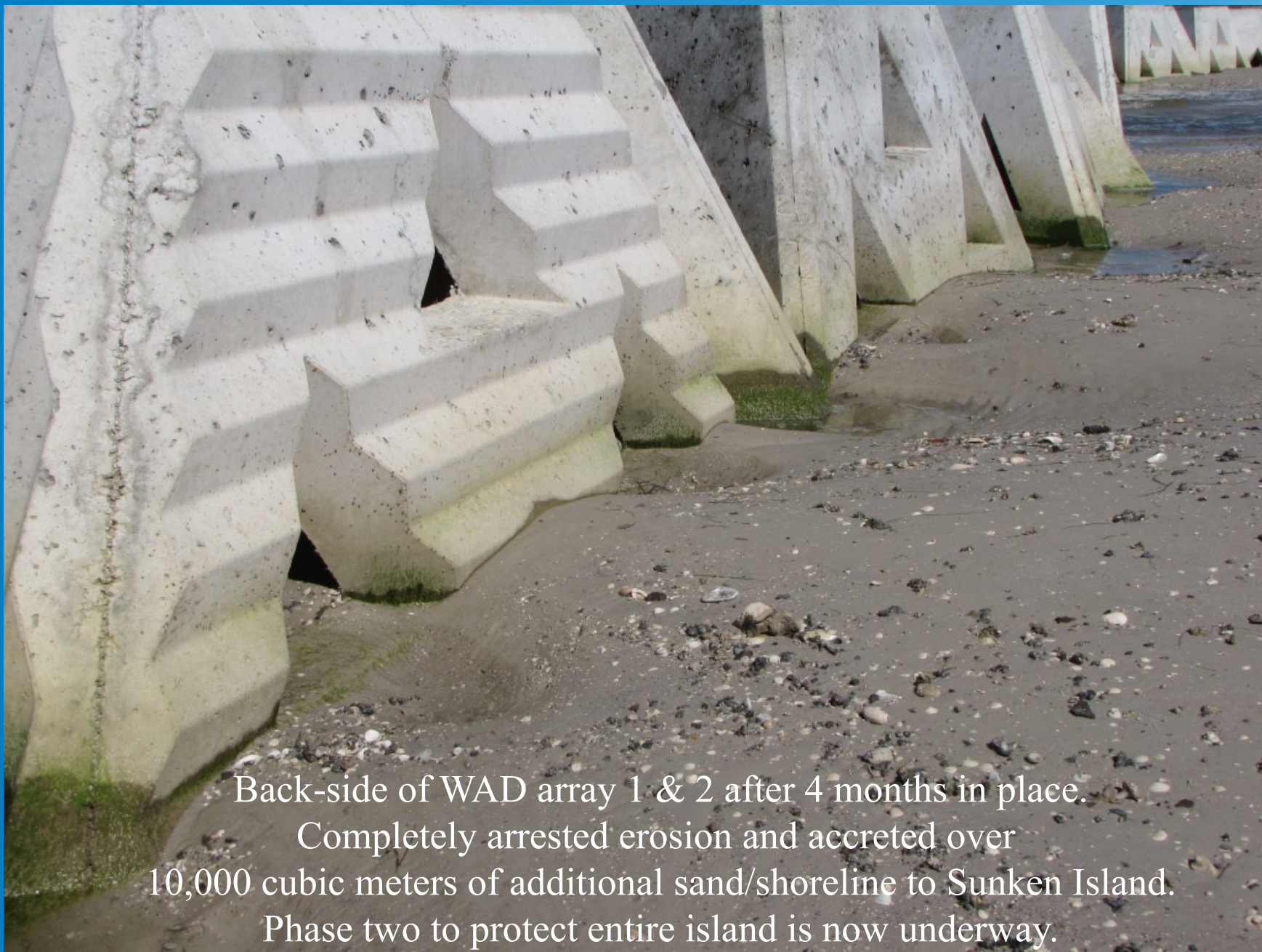


## Example of WAD effectivity Sunken Island, Tampa Bay, Florida

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Back-side of WAD array 1 & 2 after 4 months in place.  
Completely arrested erosion and accreted over  
10,000 cubic meters of additional sand/shoreline to Sunken Island.  
Phase two to protect entire island is now underway.

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Sunken & Bird Island Bird Sanctuary  
Restoration Complete January 2020  
after 10-year effort.



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# Completed Project in Negril Jamaica 39 Days after Installation

COCO PLUM DEVELOPMENTS, NEGRIL JAMAICA, W.I. INSET PICTURE TAKEN DAY BEFORE DEPLOYMENT, 21 MAY 2009



+ GAIN 60 FEET

WATERLINE @ TREES

DEPLOYMENT COMPLETE DATE 22 MAY 2009

SAT IMAGERY TAKEN ON JUNE 30 2009 39 DAYS LATER

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Imagery Date: Jun 30, 2009

© 2010 Europa Technologies

Image © 2010 GeoEye  
© 2010 Google

18°19'25.44" N 78°20'12.26" W elev 2 m

Eye alt 420 m



**+ GAIN 65 FEET**

DEPLOYMENT COMPLETE DATE 22 MAY 2009

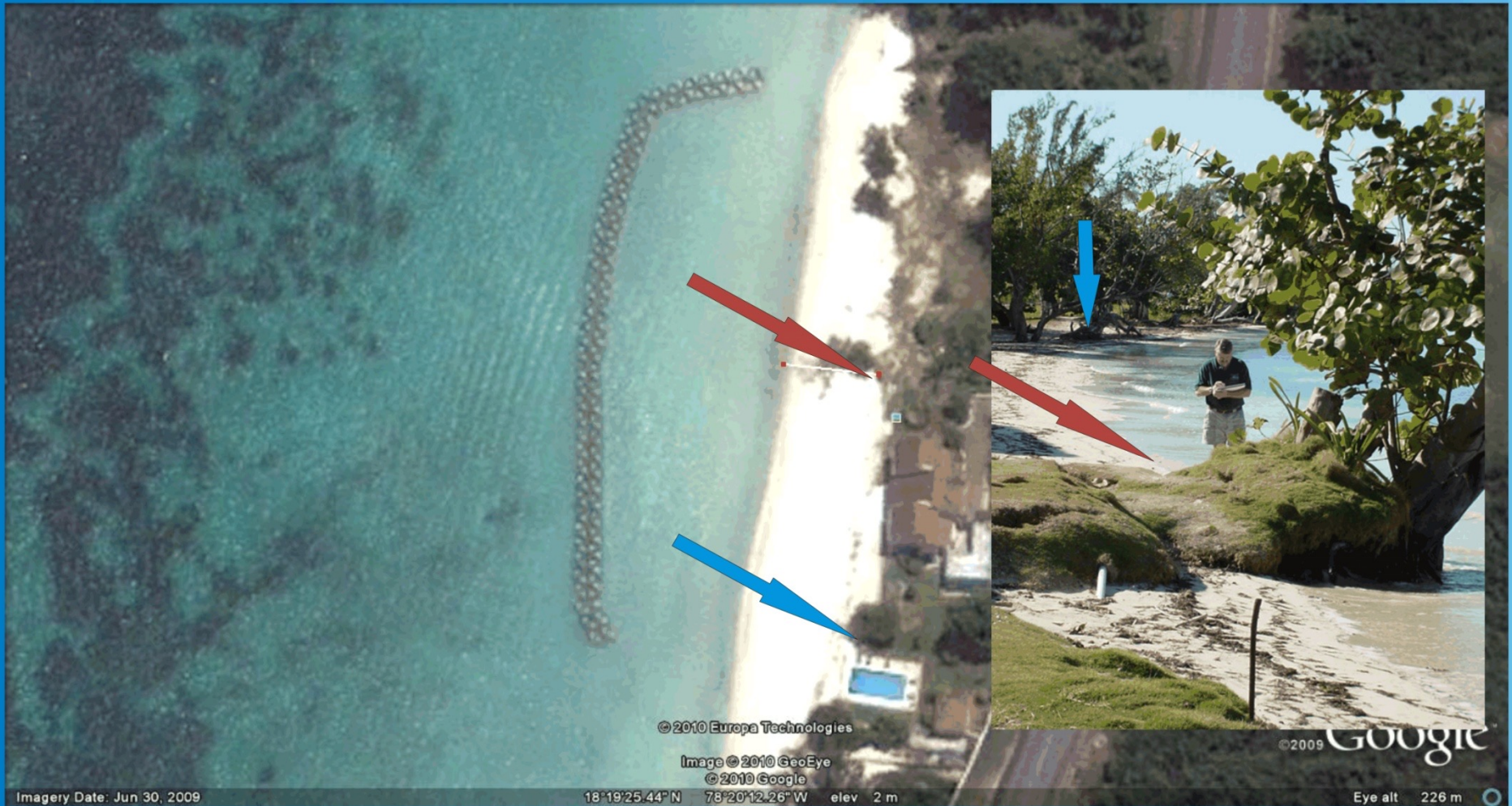
SAT IMAGERY TAKEN ON JUNE 30 2009 39 DAYS LATER

TAPE MEASURE FROM PORCH = 4 FT TO WATER

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**+ GAIN 55 FEET**

DEPLOYMENT COMPLETE DATE 22 MAY 2009

SAT IMAGERY TAKEN ON JUNE 30 2009 39 DAYS LATER

SURVEYOR STANDING IN WATER AT BENCHMARK  
NOTE BLUE ARROW FOR PERSPECTIVE

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+ GAIN 58 FEET



DEPLOYMENT COMPLETE DATE 22 MAY 2009  
SAT IMAGERY TAKEN ON JUNE 30 2009 39 DAYS LATER

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+ GAIN 75 FEET

↑ DEPLOYMENT COMPLETE DATE 22 MAY 2009

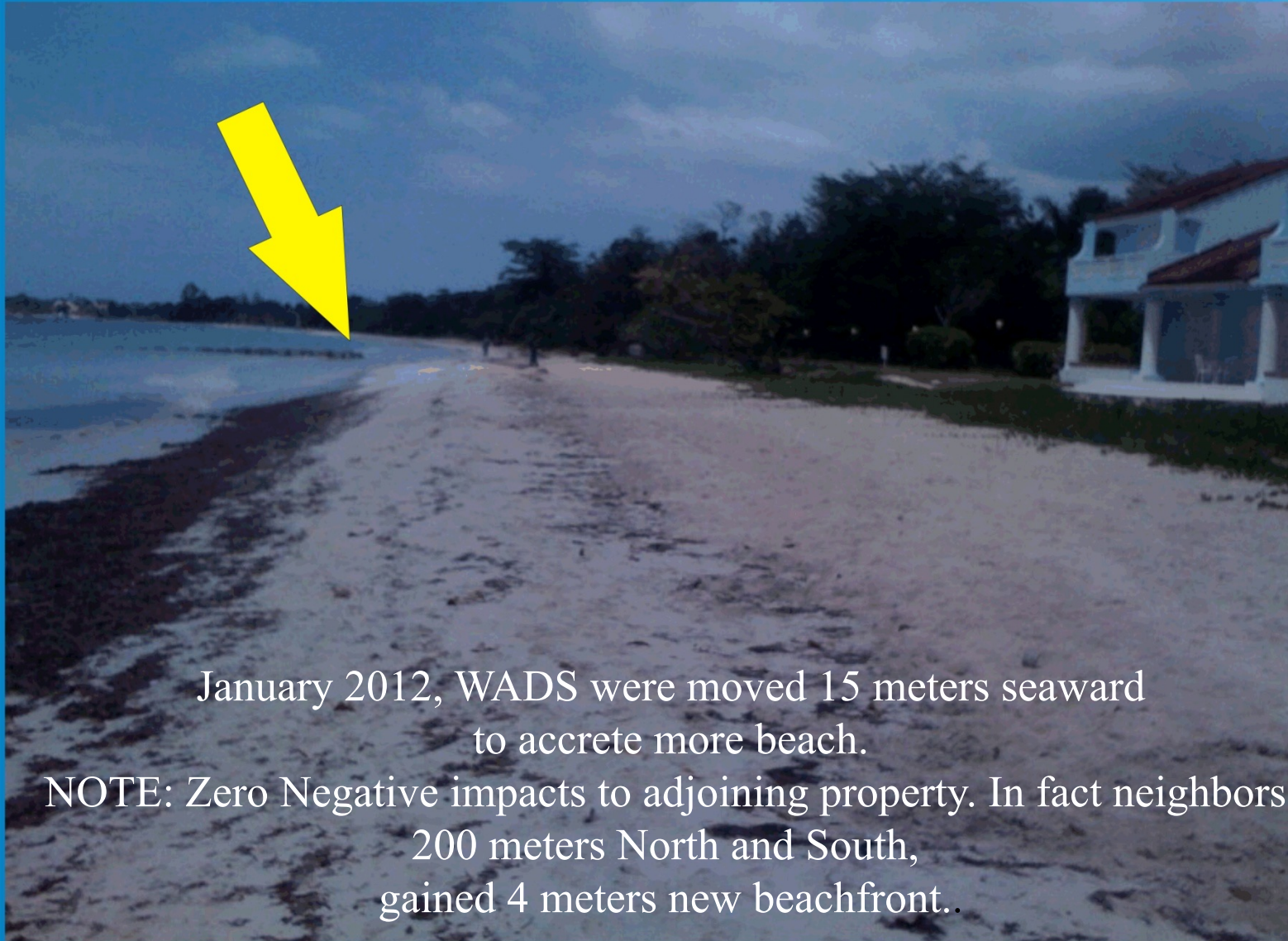
SAT IMAGERY TAKEN ON JUNE 30 2009 39 DAYS LATER

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## Note WADs and proximity to beach after 10 Months



January 2012, WADS were moved 15 meters seaward to accrete more beach.

NOTE: Zero Negative impacts to adjoining property. In fact neighbors 200 meters North and South, gained 4 meters new beachfront..

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## Negril Jamaica accretion of 14,000 cubic meters in 2 years

- WADs performed best in severe weather reduce incident wave energy
- Estimated 1,857 metric tons of additional marine biomass on an annual basis after first year
- No negative effect on adjacent area (long shore drift) only positive



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# Hotel NH Cancun Mexico Submerged Barrier Reef System



Submerged Barrier Reef



Accretion  
Aug 2011

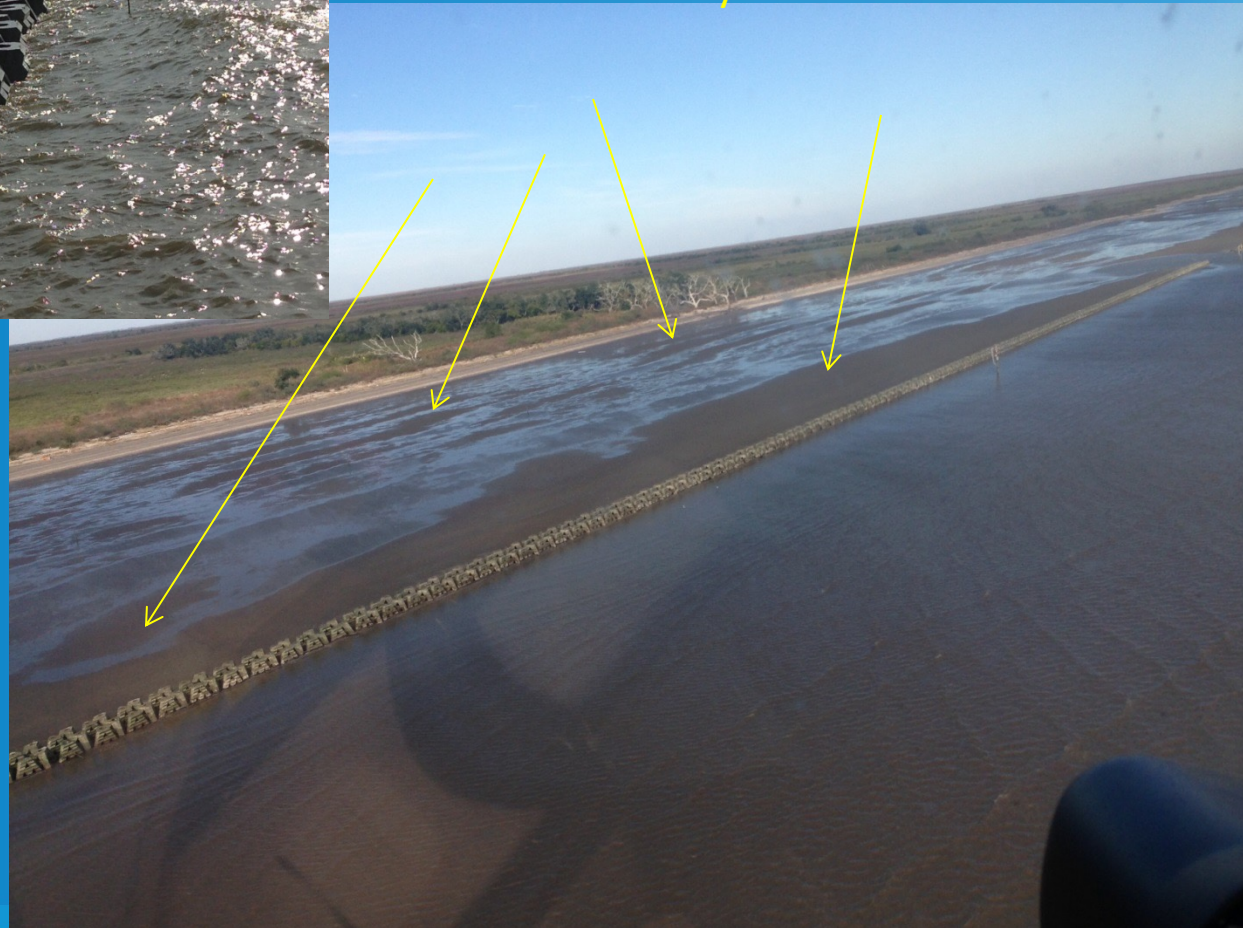
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Oyster Reef off Au-Tigre, Louisiana  
after 3 months July –November 10 2013

Even beach profile change behind WADs.  
Note accretion behind WADs, but no rough  
weather to get greater amount of sediment  
further shoreward. This is primarily oyster reef,  
well away from the shoreline



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Cape Charles, Virginia over 14,000 cubic yards of accretion and significant production Of SAV (Sub-aquatic-vegetation)



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# Cape Charles, Virginia

September 8, 2012



**Cape Charles, VA  
Low tide at  
original  
deployment (left)  
and 3 years later  
(right)**



December 21, 2015



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LA-16 USDA/NRCS Non Rock Alternative. Worst sediment conditions in the entire state with load factors not to exceed 150 PSF. WADs only free standing structure approved.

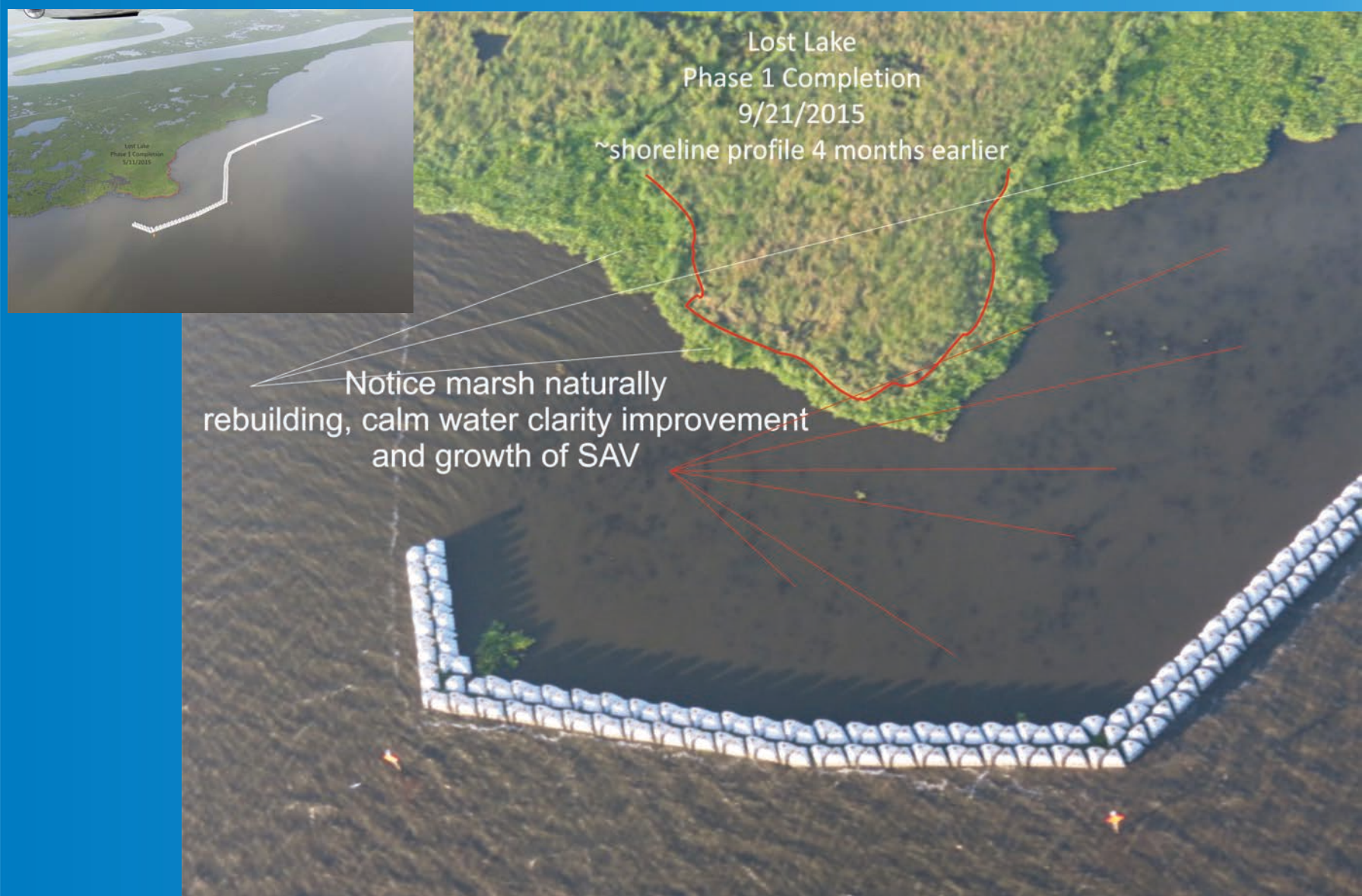


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Conoco Philips & Ducks Unlimited Phase 1 of Lost Lake Marshland Restoration.  
Project goal 10,000 Linear Feet. Completed Phase 1, April 2015.



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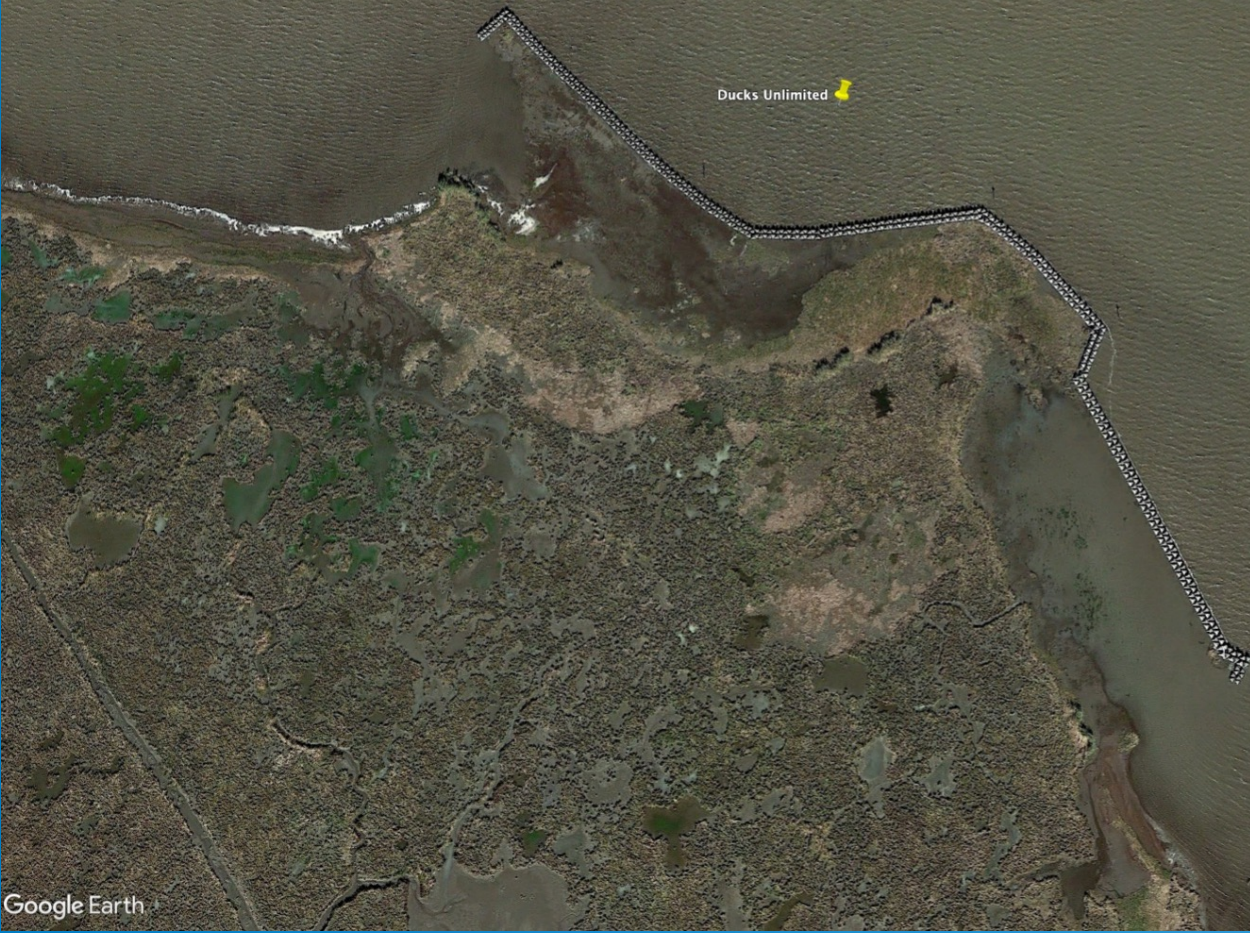


December 2019 Marsh Naturally restored out to the WAD array.

Write a description for your map.

Legend

 Ducks Unlimited



Google Earth

400 ft



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Delaware City Refinery Infrastructure Protection Project.  
Delaware River Monitoring Report In information Folder of DVD.



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# EG Simmons Park Seagrass Restoration January 2018

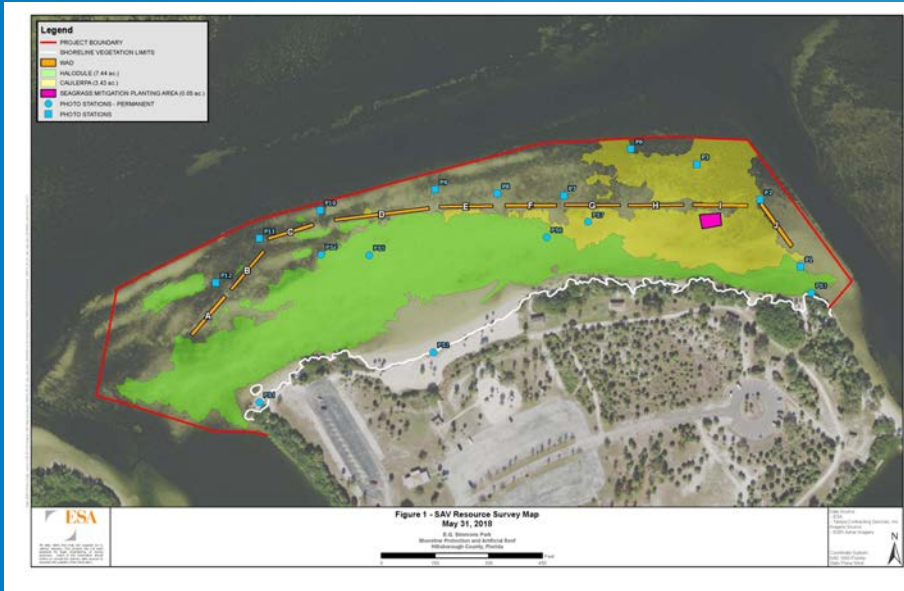


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# EG Simmons Park SAV 6 month monitoring January 2018



“The *Halodule* coverage has significantly expanded to an area of 9.69 acres, an increase of 2.25 acres from the coverage mapped in the beginning of this growing season.”

ESA Environmental Science Associates.



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➤ Effective Erosion Control

- Habitat creation/protection
- Infrastructure/property protection
- Buffer from natural processes (i.e. storms, SLR)

➤ Public Use Value

- Maintain/enhance beachfront areas and maintain land-to-water access
- Artificial reefs introduce new recreational value

➤ Environmental Value

- Ecological uplift
- Minimal impact green technology
- Passive accretion/natural habitat progression

➤ Durable and Stable Design

- Pyramidal and porous design promotes stability
- Proven to withstand major storms

➤ Versatile and Cost Effective Project Design

- Variation in array
- Variation in WAD design
- Portable
- Installation Cost = or < conventional technologies



**Allows for Tailored Design to  
Client Need and Site Specific  
Goals**

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Statistical wave conditions based on the measured directional waves at NOAA gauge 44007 from 2009 to 2020.

Angle bracket	mid-point angle	Frequency of occurrence	Average of top 1% (16' max)		Average	
			wave height	peak wave period	wave height	peak wave period
	degrees	%	m	s	M	s
0-23	11.5	1.19	2.61	10.00	0.64	4.42
23-45	33.0	0.82	4.52	12.27	0.82	5.93
45-68	56.5	1.11	4.77	11.95	0.95	7.91
68-90	79.0	5.66	4.89	11.33	1.15	8.49
90-113	101.5	18.98	5.08	11.21	1.13	9.54
113-135	124.0	25.23	4.47	10.64	0.96	9.04
135-158	146.5	25.10	3.71	9.48	0.92	7.85
158-180	169.0	11.03	3.36	8.26	0.95	6.31
180-203	191.5	5.08	2.48	7.22	0.91	4.99
203-225	214.0	1.60	2.21	8.18	0.74	4.38
225-248	236.5	0.81	1.96	9.87	0.68	4.42
248-270	259.0	0.65	2.00	10.92	0.73	4.98
270-293	281.5	0.45	2.22	13.65	0.68	6.91
293-315	304.0	0.50	1.93	13.71	0.67	6.18
315-338	326.5	0.54	1.73	11.47	0.62	5.61
338-360	349.0	1.15	1.63	7.89	0.63	4.17

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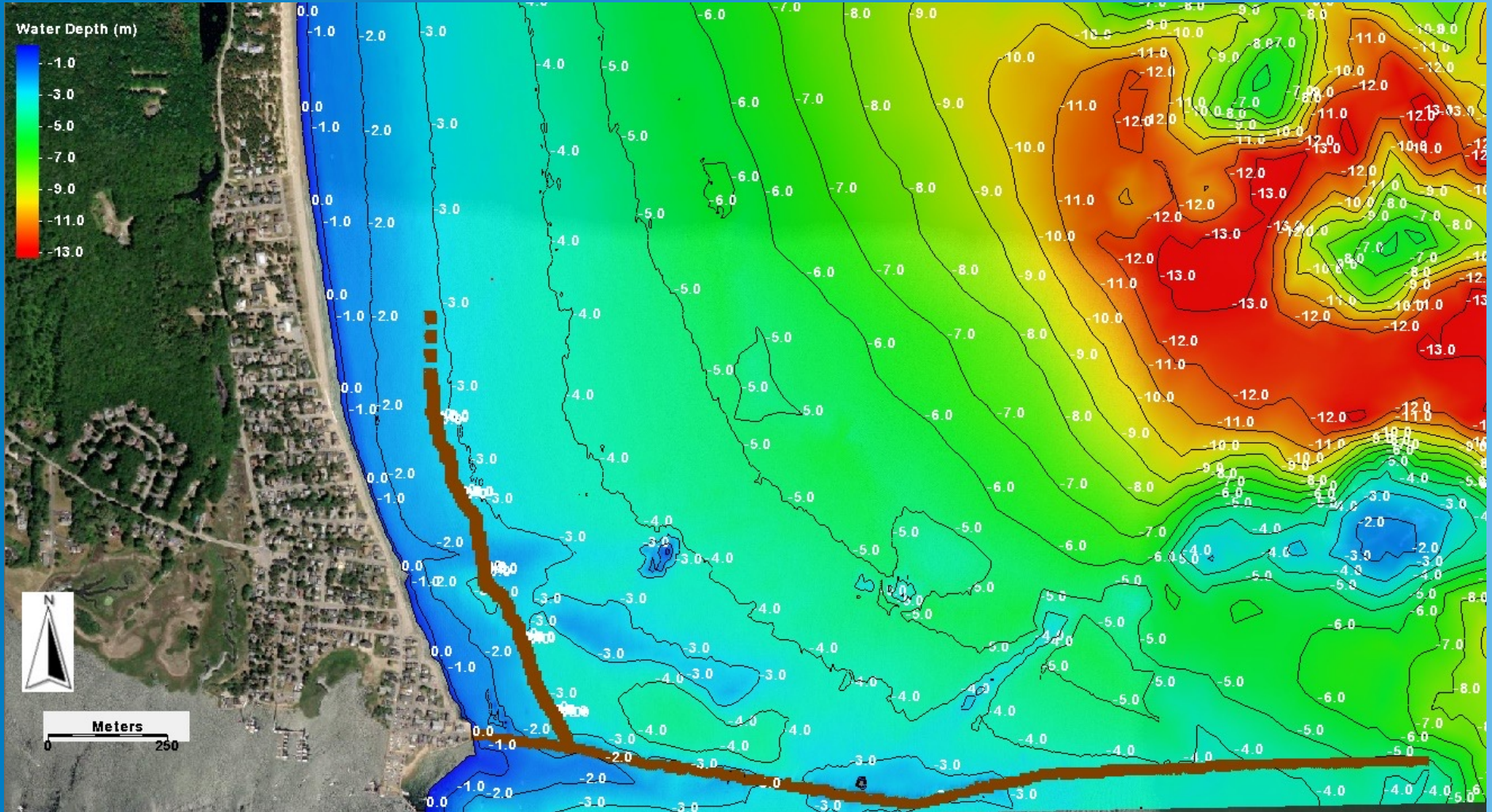


Three Alternatives: All 15' WAD @ - 8.9' contour 525' offshore

A1: 2,700+ LF Eagle Avenue

A2: 2,900+ LF Island Avenue

A3: 3,200+ LF Ferry Park

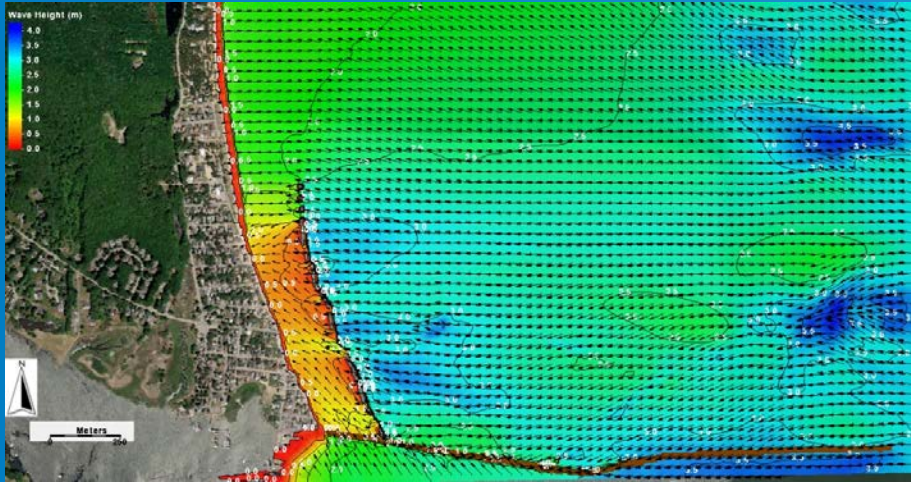


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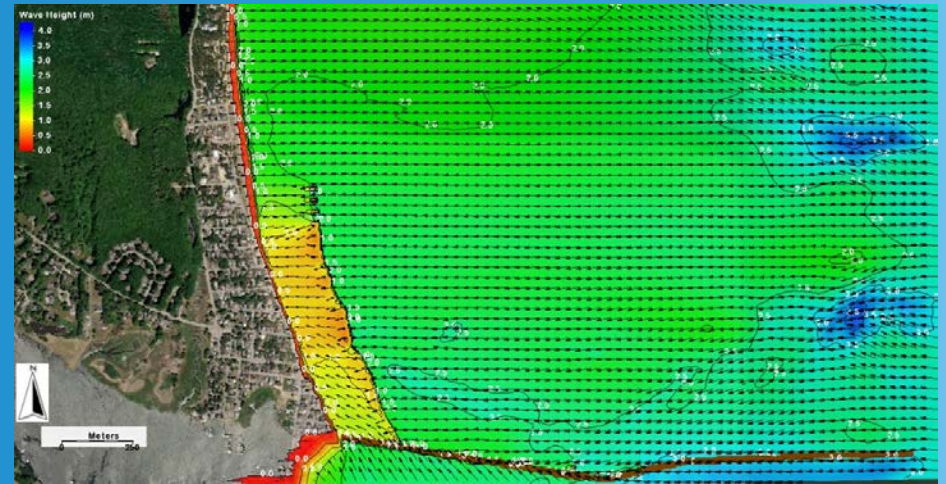
DADE CITY, FLORIDA



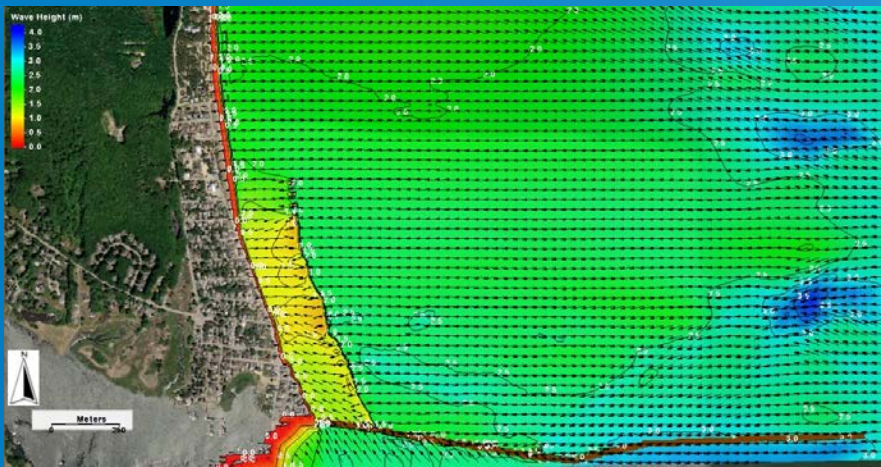
Modeled Alternative 3 (A3) wave field associated with the 124-deg offshore incident wave ( $H_{sig}=4.47$  m,  $T_p=10.64$  s) under projected higher sea level superimposed on MHHW: Top panel: 0.1 m sea-level rise, middle panel: 0.46 m sea-level rise, lower panel: 0.67 m sea-level rise.



10''



-4''



12''

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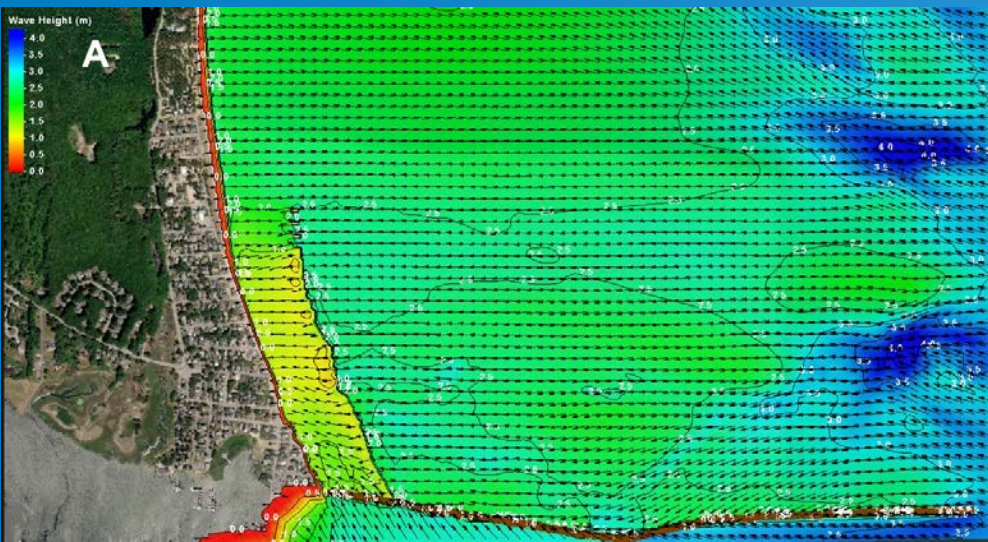
DADE CITY, FLORIDA



Extreme wave conditions used in the Woods Hole Group Environmental Laboratories and Aubrey Consulting (2006) modeling study.

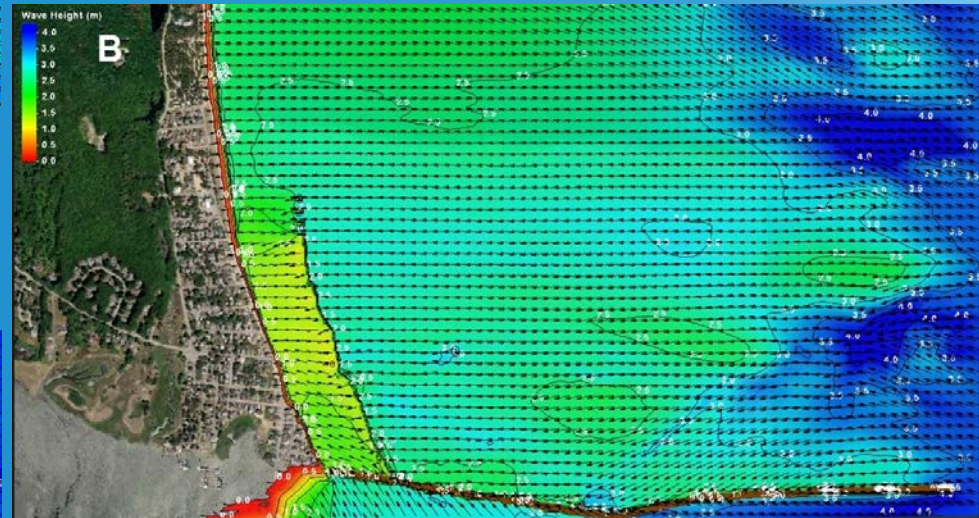
	wave height	wave period	incident angle	water level
	m	s	Degrees	m above MTL
10-year. (20+)      A	6.2	14.4	60	2.4
50-year. (23+)      B	7.1	15.4	60	2.6
100-year. (24.6)     C	7.5	15.9	60	2.7
perfect storm (22.6)     D	6.9	14.3	37	2.4
Hurricane Bob. (19)        E	5.8	11.1	-20	1.8
Noreaster. (18.3)     F	5.6	11.1	50	2.4



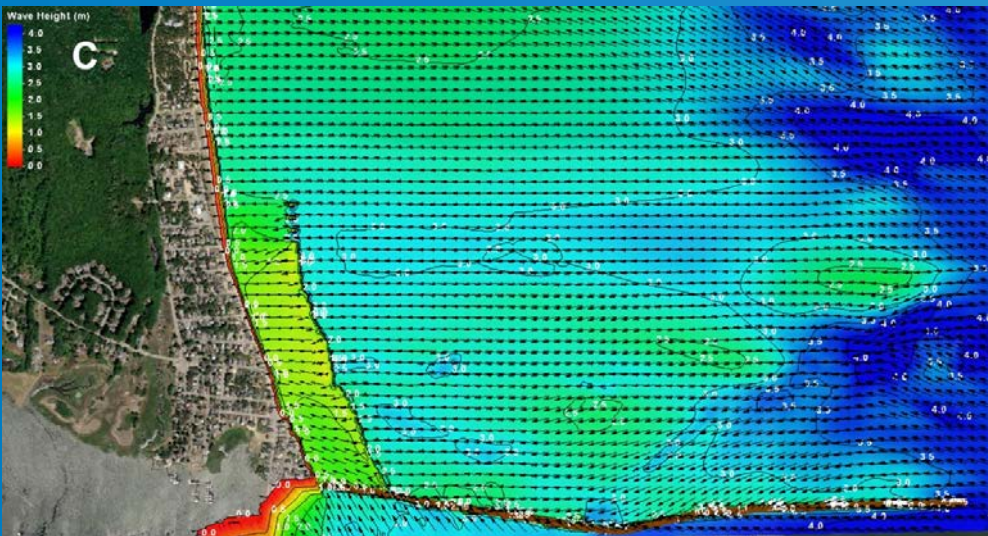


10 /20'+

50/ 23' +



100/24.6'

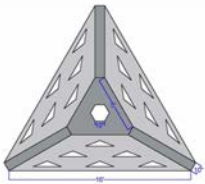


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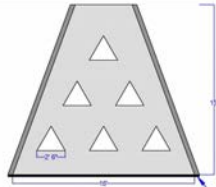






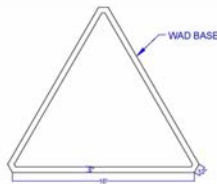
TYPICAL DETAIL

WAD  
(PLAN VIEW)



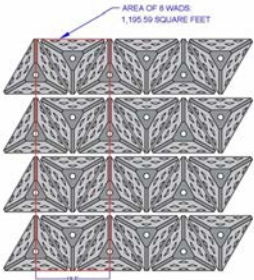
TYPICAL DETAIL

WAD  
(FRONT VIEW)



TYPICAL DETAIL

WAD BASE



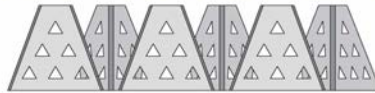
AREA OF 8 WADS  
1,195.59 SQUARE FEET

TYPICAL DETAIL

FOUR-ROW WAD  
ARRAY  
(PLAN VIEW)



NOTE:  
FRONT VIEW OF FOUR-ROW ARRAY ONLY SHOWS FIRST TWO ROWS; THIRD AND  
FOURTH ROWS ARE LOCATED DIRECTLY BEHIND THE FIRST AND SECOND ROWS



TYPICAL DETAIL

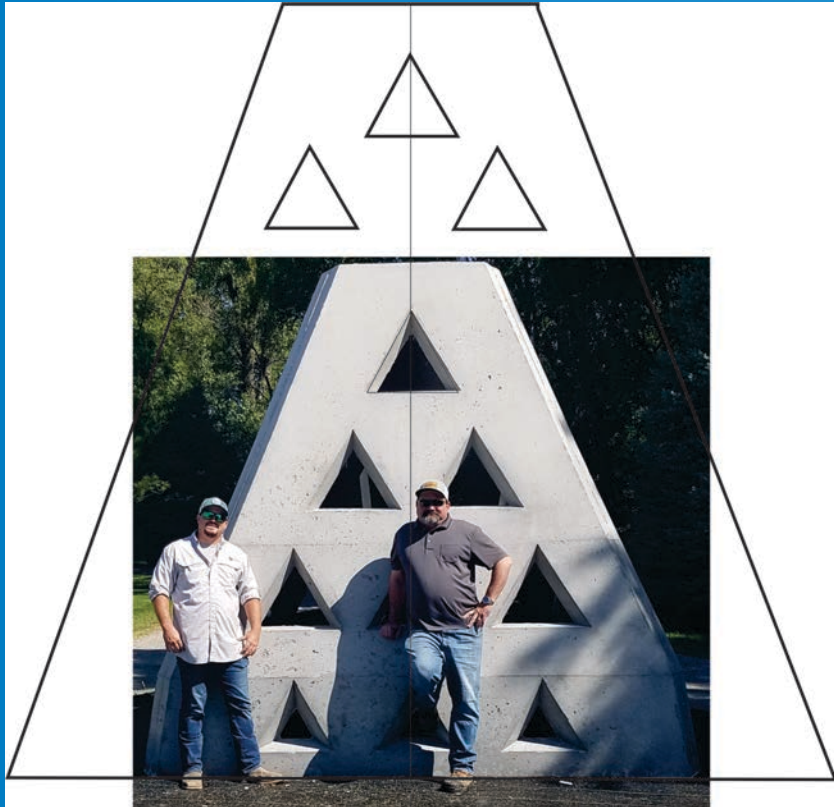
FOUR-ROW WAD  
ARRAY  
(FRONT VIEW)



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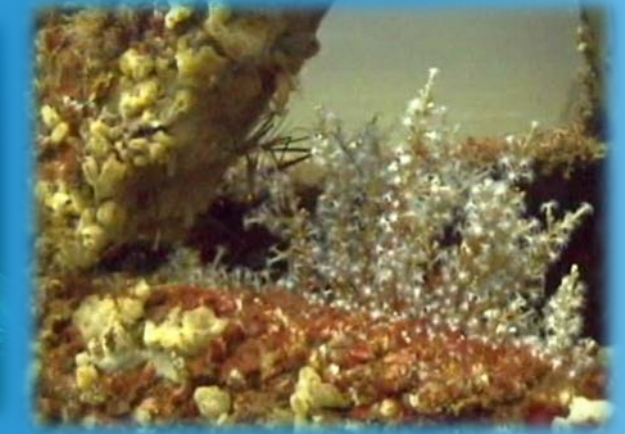


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Fish Havens® provide dynamic, complex, marine life habitat and durable, stable and highly productive Essential Fish Habitat (EFH).



**Measured: 0.47 metric tons of biomass production / meter<sup>2</sup> of surface area annually.**

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# Executive Summary on Fish Haven® Productivity. “..... every square meter of..substrate...produces 0.47 metric tons of marine biomass annually...”

Rodney Garner (GCMarSt)  
Queensland, Australia.

## EXECUTIVE SUMMARY FISH HAVEN ARTIFICIAL REEFS PRODUCTIVITY

Artificial Reefs, Incorporated (ARI) & Coastal Restoration, Incorporated (CRI) USA, are sister engineering Firms involved with professional, “state-of-the-art” reef development and coastal protection projects. They hold numerous intellectual property rights and U.S. & International Patent rights (US 6,186,702B1) (International Patent Application No. PCT/US99/00101, filed March 3, 1999 PCT Docket No# 4480) These units are the result of the design and development of the World’s Only “Scientific” marine life habitat/wave attenuation device available. The Fish Haven/Coastal Haven series modules were specifically designed to have the same marine life habitat characteristics of natural reefs. The Fish Haven/Coastal Haven series modules were specifically designed to have the same rapid marine growth on all hard substrate surfaces as natural reefs. The Fish Haven series modules were specifically engineered to act as wave attenuation devices.



The hydrodynamic engineered shape was specifically developed to promote a “designed” surface. Combined with the engineered light reflecting surfaces, the Fish Haven series modules promote biomass development and reef productivity. The amount of productive, hard substrate and space available. The Fish Haven/ Coastal Haven series “designed” reef /wave attenuation systems on a developmental substrate and a more stable and productive biomass development. These features allow fish to establish a column when seeking optimum current and temperature.



several different size Fish Haven units, with designed to be placed inside the larger outer unit. This permits the units to be protected and to thrive. Units and components are placed apart in small patch reef configurations. As the units are placed and transit corridors between patches, develop.



At the six month, through one-year point, reports were received from the reefs. Additionally, numerous transects were taken on the reefs. Size estimates (per surface area) recorded at a distance of 15 meters from the reef structures. Unit measurements were taken from both patch reef configurations. In our typical patch reef configuration, with reef units spaced at a lower-observed average of 115.6 kilograms/meters square, an average of 138.5 kilograms/meters square of marine fish biomass (resident reef species, crustaceans, etc.)

accelerating the development of those new patches. One notable project done in the Gulf of Mexico was to place 750 Fish Haven Artificial Reef Systems in 12 weeks’ time, covering an area of 15m<sup>2</sup> in 85 feet of water. The Fish Haven Artificial Reef System (24m<sup>2</sup>/unit of productive substrate) produced 15m<sup>2</sup>/unit of productive substrate. Juniors (4m<sup>2</sup>/unit of productive substrate) produced 12,750 m<sup>2</sup> of productive substrate per unit. Recommendations of the Fish Haven Artificial Reef System in Australia and close of the Fish Haven Artificial Reef System.



Over the past 9 years, Artificial Reefs Inc. has placed over 12,000 artificial reefs systems, performing numerous studies and observations, we have been able to establish a base-line, conservative, estimate on marine life productivity, based on the productive substrate of the Fish Haven System. That estimated number is, that for every square meter of productive substrate provided for in a designed artificial, Fish Haven, patch reef system, there will be, conservatively, a total of: 0.47 metric tons of marine biomass produced on an annual basis.



Centre for Marine Studies

Rodney Garner  
Graduate Certificate of Marine Studies (GCMarSt)

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## Please Contact

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