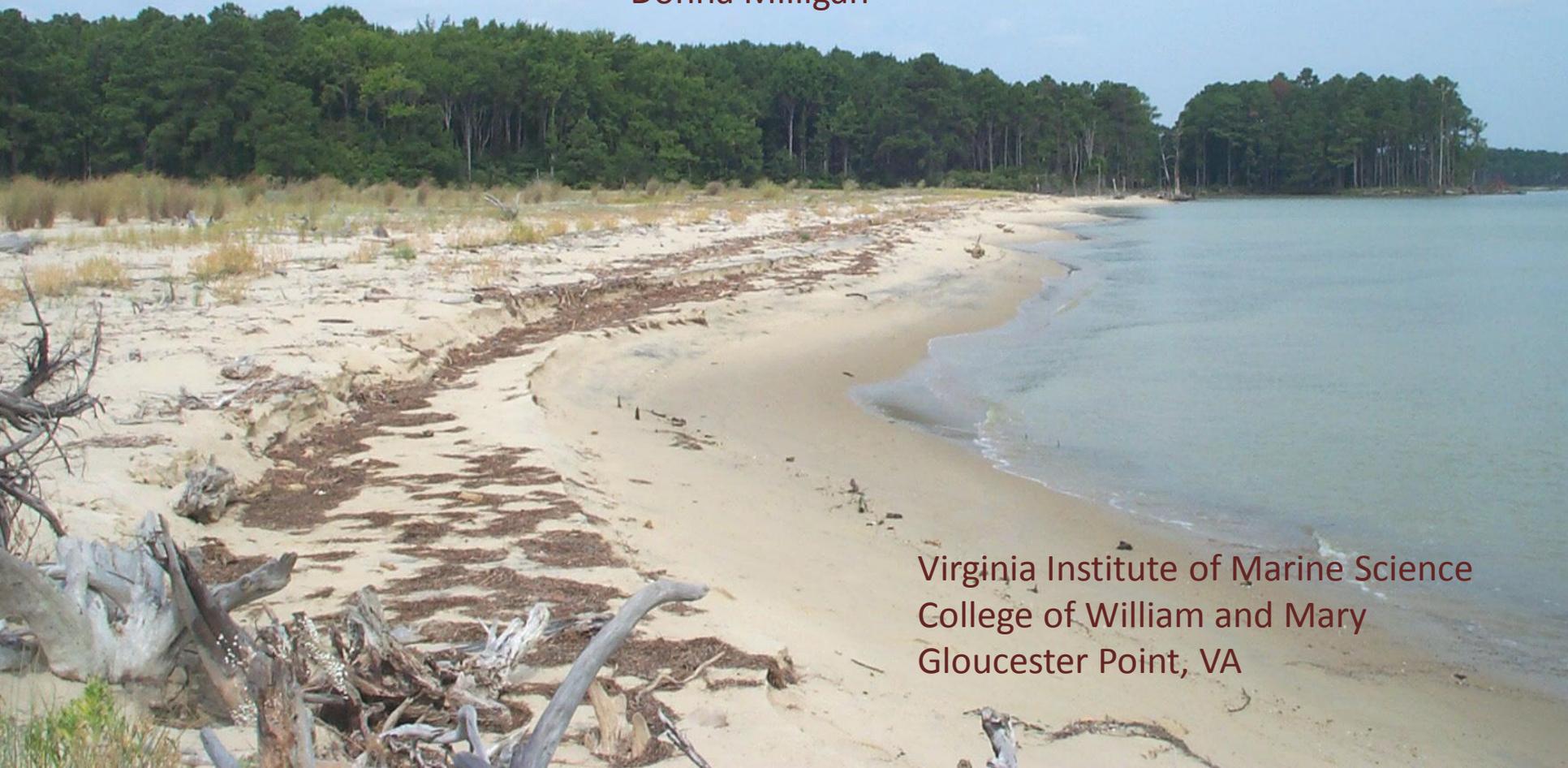


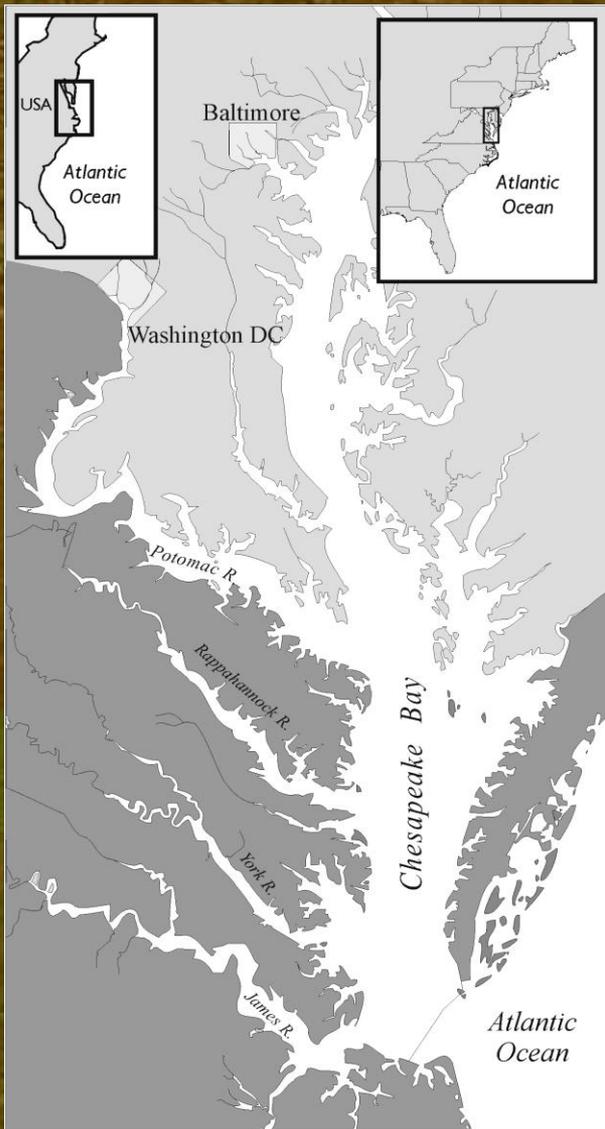
# Classification of Fetch Limited Dunes in the Lower Chesapeake Bay: Evidence of Morphologic Equilibrium

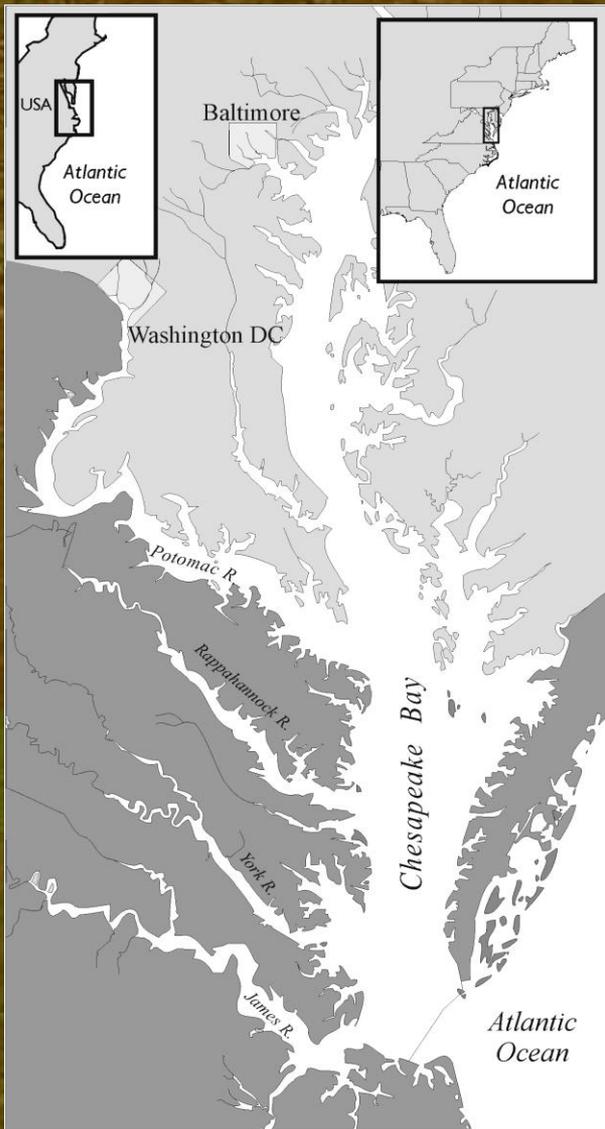
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Lyle M. Varnell  
C. Scott Hardaway, Jr.  
Donna Milligan

Virginia Institute of Marine Science  
College of William and Mary  
Gloucester Point, VA



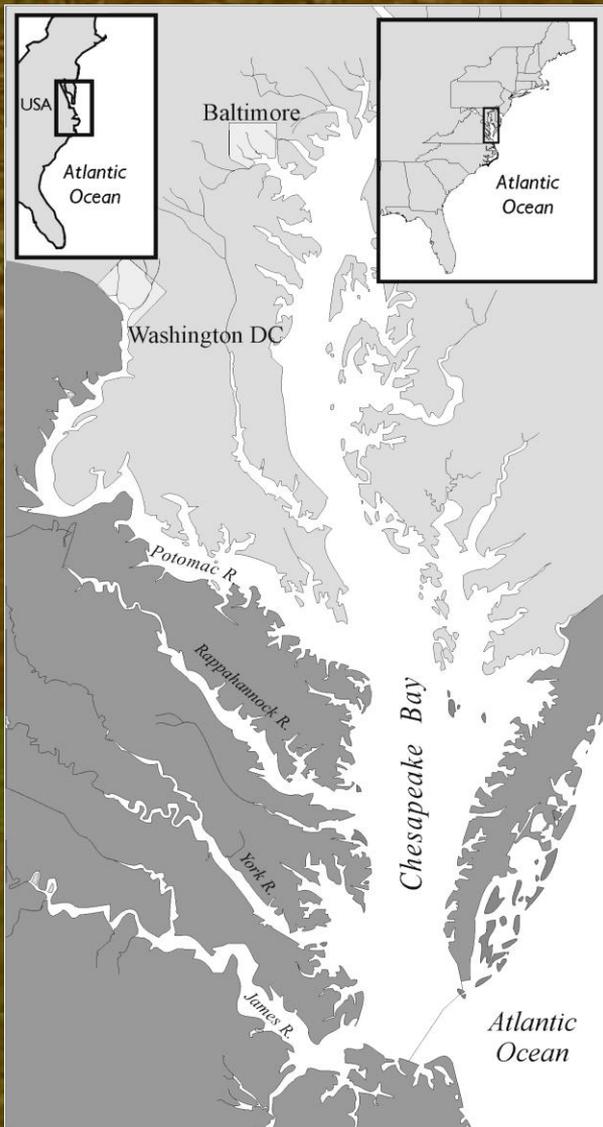




11,608 km (7,212 miles) of tidal Bay shoreline







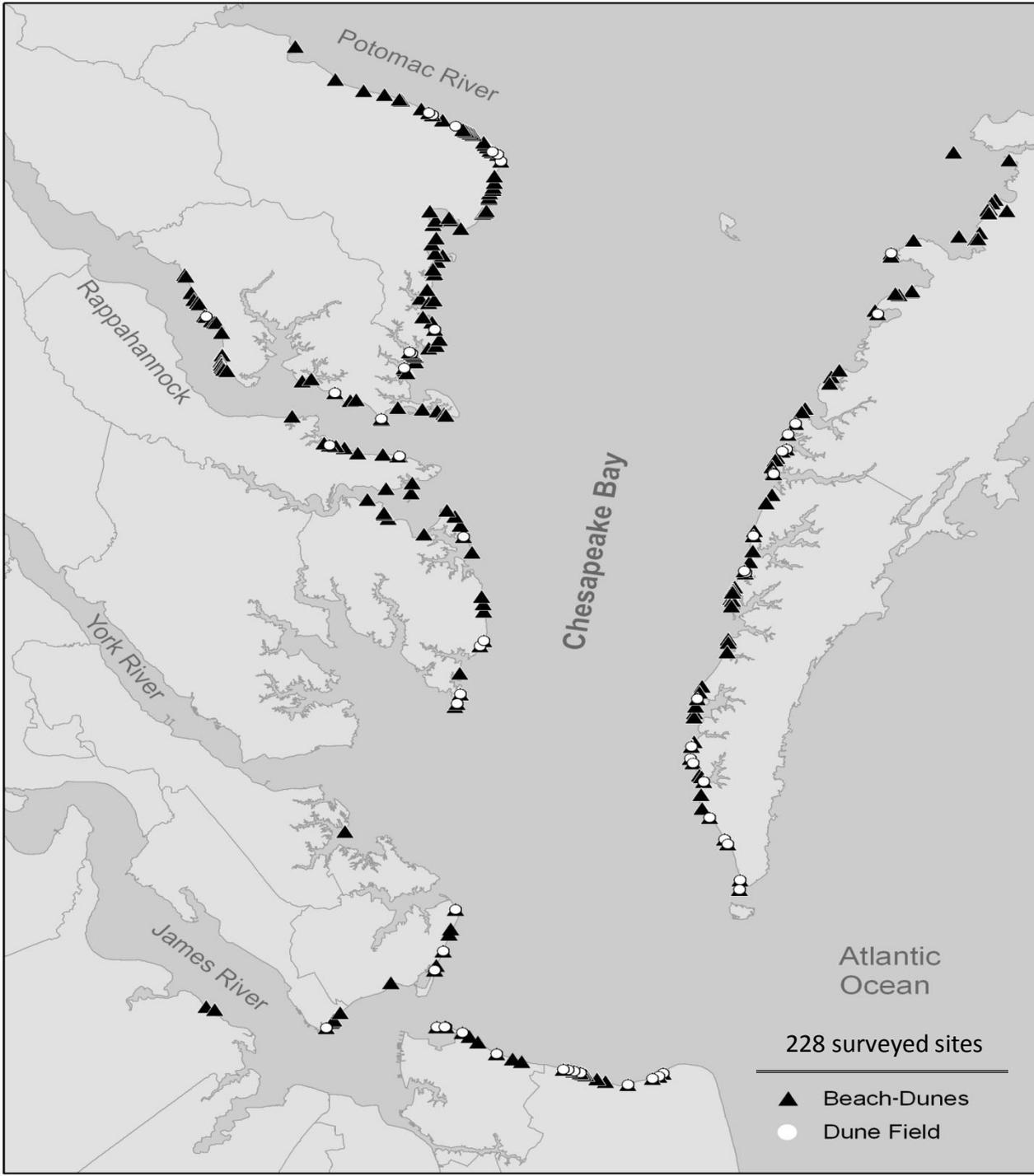
- 11,608 km (7,212 miles) of tidal Bay shoreline

- 253 km (157 miles) of sandy Bay shoreline (2.2% of tidal Bay shoreline)

- 91.8 km (57 miles) of dunes (36% of sandy shore component and 0.8% of total tidal shoreline)

- 30.6 km (19 miles) of dune fields (33% of dunes, 12% of sandy Bay shoreline, and 0.26% of total tidal shoreline)





LAWS OF VIRGINIA RELATING TO THE MARINE RESOURCES OF THE  
COMMONWEALTH

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CHAPTER 14.

**Coastal Primary Sand Dunes and Beaches.**

**Article 1.**

**General Provisions.**

Sec.

28.2-1400.	Definitions.
28.2-1401.	Powers and duties of Commission
28.2-1402.	[Expired.]

Sec.

28.2-1407.	Administrative procedures.
28.2-1408.	Standards for use of coastal primary sand dunes.
28.2-1408.1.	[Expired.]
28.2-1409.	[Not set out.]
28.2-1410	Commissioner to review all decisions of wetlands boards.
28.2-1411.	When Commission to review decisions of wetlands boards.
28.2-1412.	Procedure for review; notice of decision.
28.2-1413.	When Commission to modify, remand or reverse decision of wetlands board.
28.2-1414.	Time for issuance of permit.
28.2-1415.	Judicial review.

**Article 2.**

**Coastal Primary Sand Dune Ordinance and Boards.**

28.2-1403.	Certain counties, cities and towns authorized to adopt coastal primary sand dune ordinance.
28.2-1404.	Meetings, quorum, rules, etc., of wetlands boards; records and reports.
28.2-1405.	Local governing body to supply meeting space and services for wetlands boards.

**Article 3.**

**Permits and Review.**

28.2-1406.	Permits required for certain activities; issuance of permits by Commission.
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28.2-1416.	Investigations and prosecutions.
28.2-1417.	Monitoring, inspections, compliance, and restoration.
28.2-1418.	Violations. penalty.
28.2-1419.	Injunctions.
28.2-1420.	Penalties.

**Article 4.**

**Enforcement and Penalties.**

# Fetch-Limited Dune Classification System

## *I. Natural*

## *II. Man-Influenced*

## *III. Man-made*

### **A. Exposure: fetch**

1. Riverine, Bay Influenced
2. Open Bay
3. Riverine

### **B. Shore Orientation** (direction of face)

- |              |              |
|--------------|--------------|
| 1. North     | 5. South     |
| 2. Northeast | 6. Southwest |
| 3. East      | 7. West      |
| 4. Southeast | 8. Northwest |

### **C. Nearshore Gradient**

(to the 6 ft contour)

- |                      |                   |
|----------------------|-------------------|
| 1. 0 to 1,000 ft     | <i>.1 Bars</i>    |
| 2. 1,000 to 3,000 ft | <i>.2 No Bars</i> |
| 3. >3,000 ft         |                   |

### **D. Morphologic Setting**

1. Pocket
2. Linear
3. Shallow Bay (curvilinear)
4. Salient (point)
5. Creek Mouth Barrier
6. Spit

### **E. Relative Stability**

1. Stable
2. Accretionary
3. Land Transgressive/Erosional

### **F. Geologic Underpinnings**

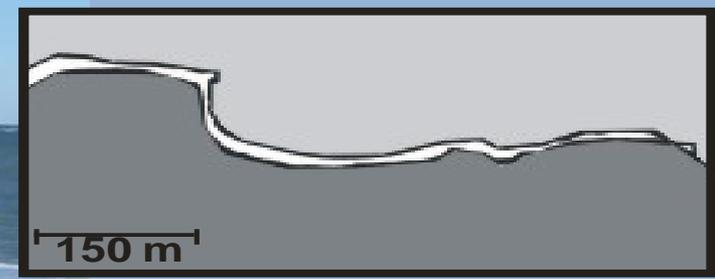
1. Marsh
2. Upland

### **G. Structure/Fill**

1. Groin
2. Revetment/Bulkhead
3. Breakwater
4. Jetty
5. Beach Fill

### **H. Secondary Dune(s)**

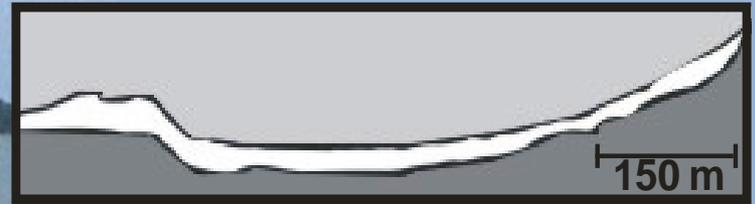
1. Present
2. Absent



**Pocket**



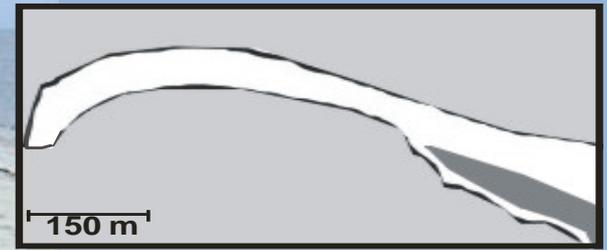
**Linear**



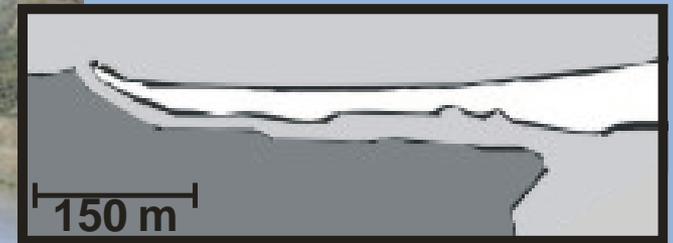
**Shallow Bay**



**Salient**



**Spit**



**Creek Mouth  
Barrier**

## Morphologic Setting

Classification	Pocket	Linear	Shallow Bay	Salient	Creek Mouth Barrier	Spit
<b>Total</b>	<b>27</b> (2.4)	<b>118</b> (46.4)	<b>19</b> (4.4)	<b>8</b> (1.4)	<b>42</b> (7.0)	<b>14</b> (3.0)
<b>Primary Affect</b>						
Natural	10 (0.77)	51 (22.2)	12 (3.19)	5 (1.06)	21 (2.66)	12 (2.54)
Man-Influenced	17 (1.68)	64 (23.0)	7 (1.17)	3 (0.33)	21 (4.31)	2 (0.44)
Man-made	0	3 (1.25)	0	0	0	0
<b>Fetch Exposure</b>						
Riverine, Bay influenced	4 (0.18)	15 (2.60)	7 (1.22)	3 (0.35)	7 (0.73)	3 (0.39)
Open Bay	18 (1.82)	86 (41.2)	9 (2.34)	3 (0.73)	21 (4.97)	8 (2.40)
Riverine	5 (0.44)	17 (2.63)	3 (0.80)	2 (0.31)	14 (1.27)	3 (0.19)
<b>Shoreline Orientation</b>						
North	3 (0.53)	18 (10.1)	2 (0.37)	1 (0.08)	6 (0.58)	0
Northeast	3 (0.47)	25 (7.50)	6 (1.41)	2 (0.14)	9 (1.15)	2 (0.28)
East	13 (1.00)	16 (6.04)	1 (0.30)	0	7 (2.00)	0
Southeast	2 (0.14)	2 (0.32)	2 (0.52)	1 (0.49)	3 (1.22)	2 (0.14)
South	3 (0.15)	3 (0.42)	1 (0.20)	2 (0.33)	2 (0.43)	1 (0.08)
Southwest	1 (0.08)	11 (4.31)	3 (0.53)	0	5 (0.37)	0
West	1 (0.06)	18 (8.14)	3 (0.46)	2 (0.35)	7 (0.85)	6 (2.14)
Northwest	1 (0.03)	25 (9.55)	1 (0.56)	0	3 (0.37)	3 (0.34)
<b>Secondary Dunes</b>						
Present	5 (0.83)	35 (24.1)	5 (1.54)	5 (1.00)	9 (0.31)	1 (0.21)
Absent	22 (1.62)	83 (22.3)	14 (2.83)	3 (0.38)	33 (4.16)	13 (2.77)
<b>Geologic Underpinnings</b>						
Marsh	12 (1.17)	40 (11.8)	7 (1.76)	1 (0.49)	39 (6.57)	8 (2.08)
Upland	15 (1.28)	78 (34.6)	12 (2.61)	7 (0.90)	3 (0.40)	6 (0.90)

Kilometers of shoreline are in parentheses

## Morphologic Setting

Classification	Pocket	Linear	Shallow Bay	Salient	Creek Mouth Barrier	Spit
<b>Total</b>	<b>27</b> (2.4)	<b>118</b> (46.4)	<b>19</b> (4.4)	<b>8</b> (1.4)	<b>42</b> (7.0)	<b>14</b> (3.0)
<b>Primary Affect</b>						
Natural	10 (0.77)	51 (22.2)	12 (3.19)	5 (1.06)	21 (2.66)	12 (2.54)
Man-Influenced	17 (1.68)	64 (23.0)	7 (1.17)	3 (0.33)	21 (4.31)	2 (0.44)
Man-made	0	3 (1.25)	0	0	0	0
<b>Fetch Exposure</b>						
Riverine, Bay influenced	4 (0.18)	15 (2.60)	7 (1.22)	3 (0.35)	7 (0.73)	3 (0.39)
Open Bay	18 (1.82)	86 (41.2)	9 (2.34)	3 (0.73)	21 (4.97)	8 (2.40)
Riverine	5 (0.44)	17 (2.63)	3 (0.80)	2 (0.31)	14 (1.27)	3 (0.19)
<b>Shoreline Orientation</b>						
North	3 (0.53)	18 (10.1)	2 (0.37)	1 (0.08)	6 (0.58)	0
Northeast	3 (0.47)	25 (7.50)	6 (1.41)	2 (0.14)	9 (1.15)	2 (0.28)
East	13 (1.00)	16 (6.04)	1 (0.30)	0	7 (2.00)	0
Southeast	2 (0.14)	2 (0.32)	2 (0.52)	1 (0.49)	3 (1.22)	2 (0.14)
South	3 (0.15)	3 (0.42)	1 (0.20)	2 (0.33)	2 (0.43)	1 (0.08)
Southwest	1 (0.08)	11 (4.31)	3 (0.53)	0	5 (0.37)	0
West	1 (0.06)	18 (8.14)	3 (0.46)	2 (0.35)	7 (0.85)	6 (2.14)
Northwest	1 (0.03)	25 (9.55)	1 (0.56)	0	3 (0.37)	3 (0.34)
<b>Secondary Dunes</b>						
Present	5 (0.83)	35 (24.1)	5 (1.54)	5 (1.00)	9 (0.31)	1 (0.21)
Absent	22 (1.62)	83 (22.3)	14 (2.83)	3 (0.38)	33 (4.16)	13 (2.77)
<b>Geologic Underpinnings</b>						
Marsh	12 (1.17)	40 (11.8)	7 (1.76)	1 (0.49)	39 (6.57)	8 (2.08)
Upland	15 (1.28)	78 (34.6)	12 (2.61)	7 (0.90)	3 (0.40)	6 (0.90)

Kilometers of shoreline are in parentheses

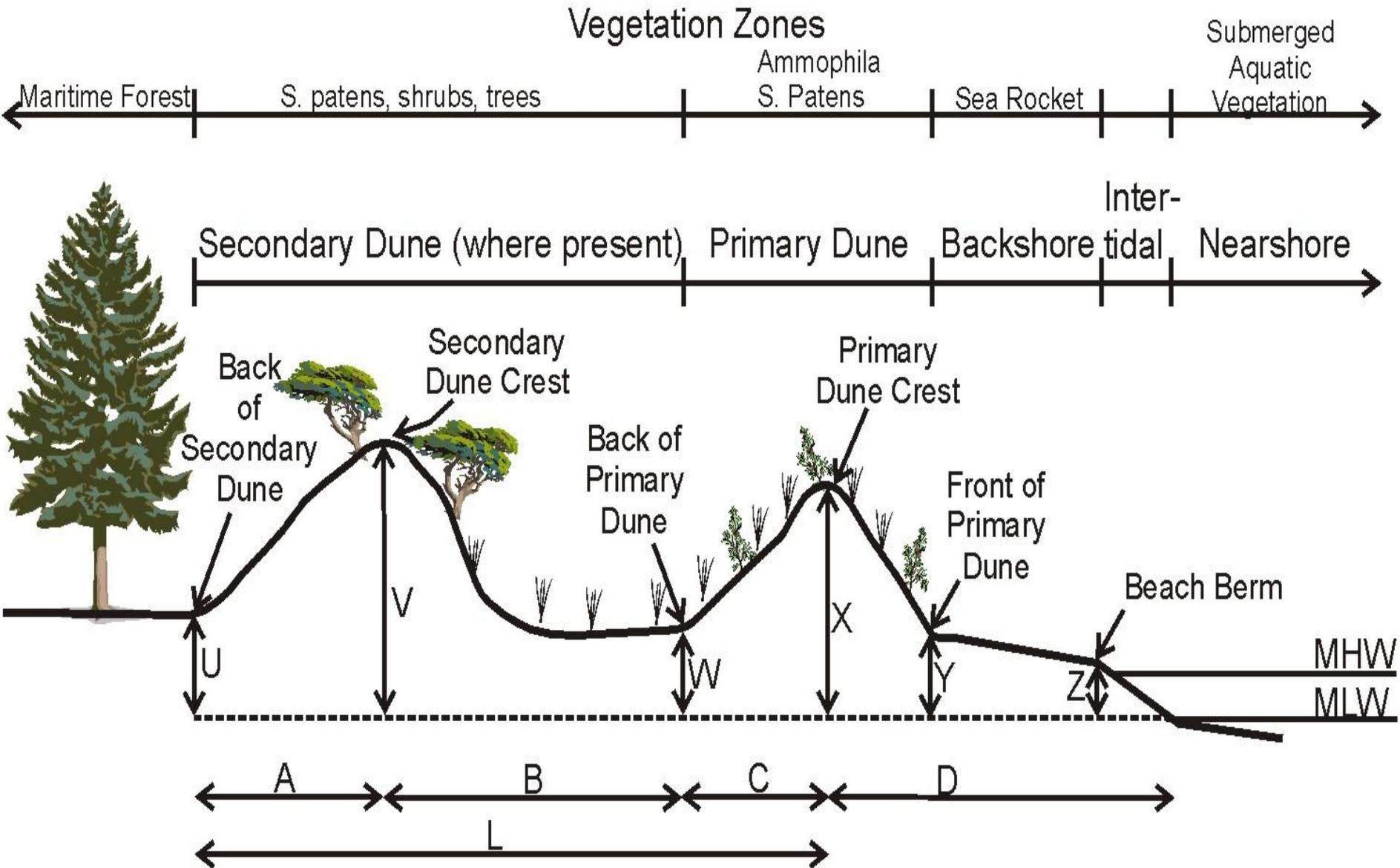


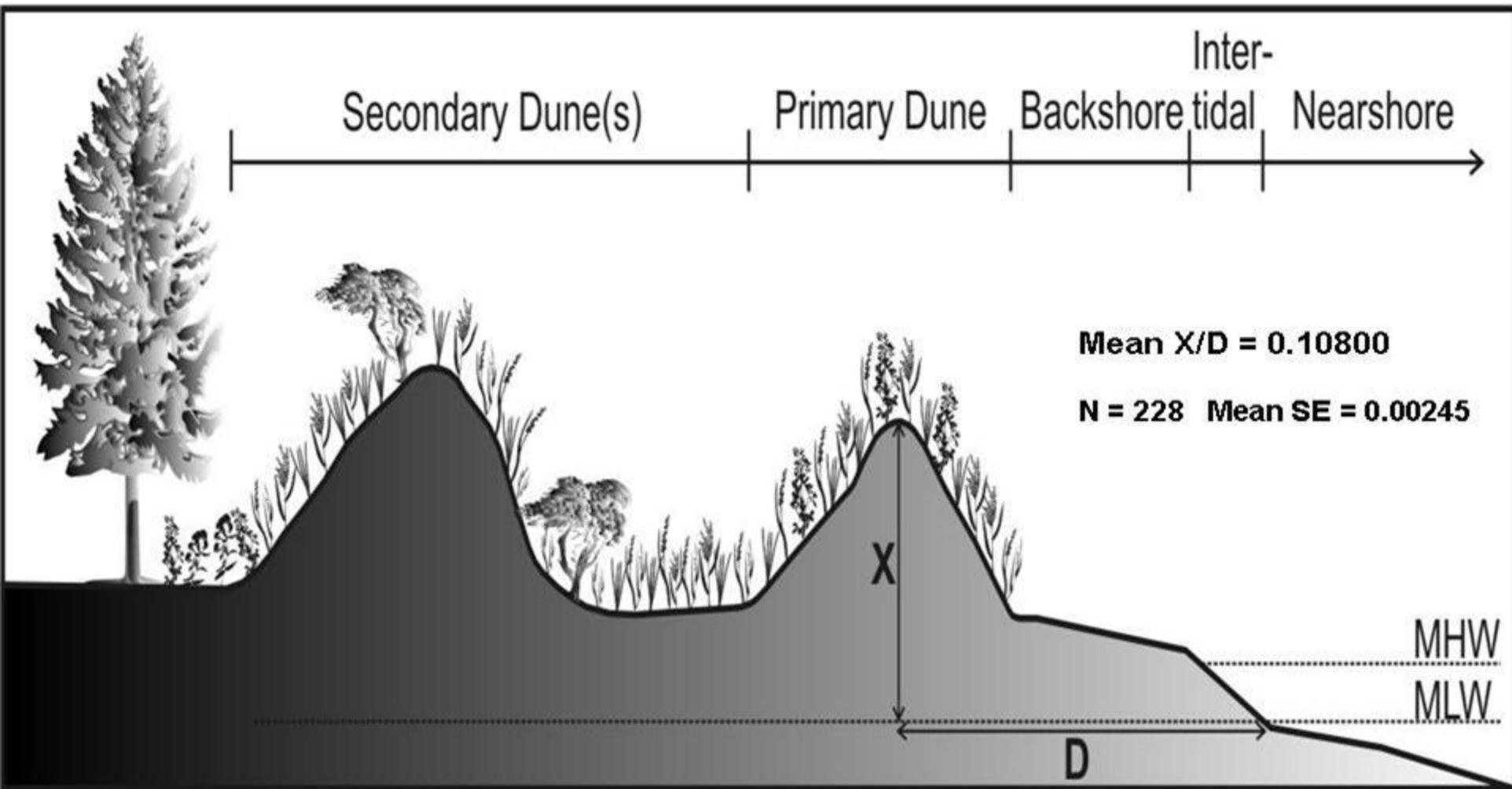


## Cross-sectional surveys



# Chesapeake Bay Dune Profile





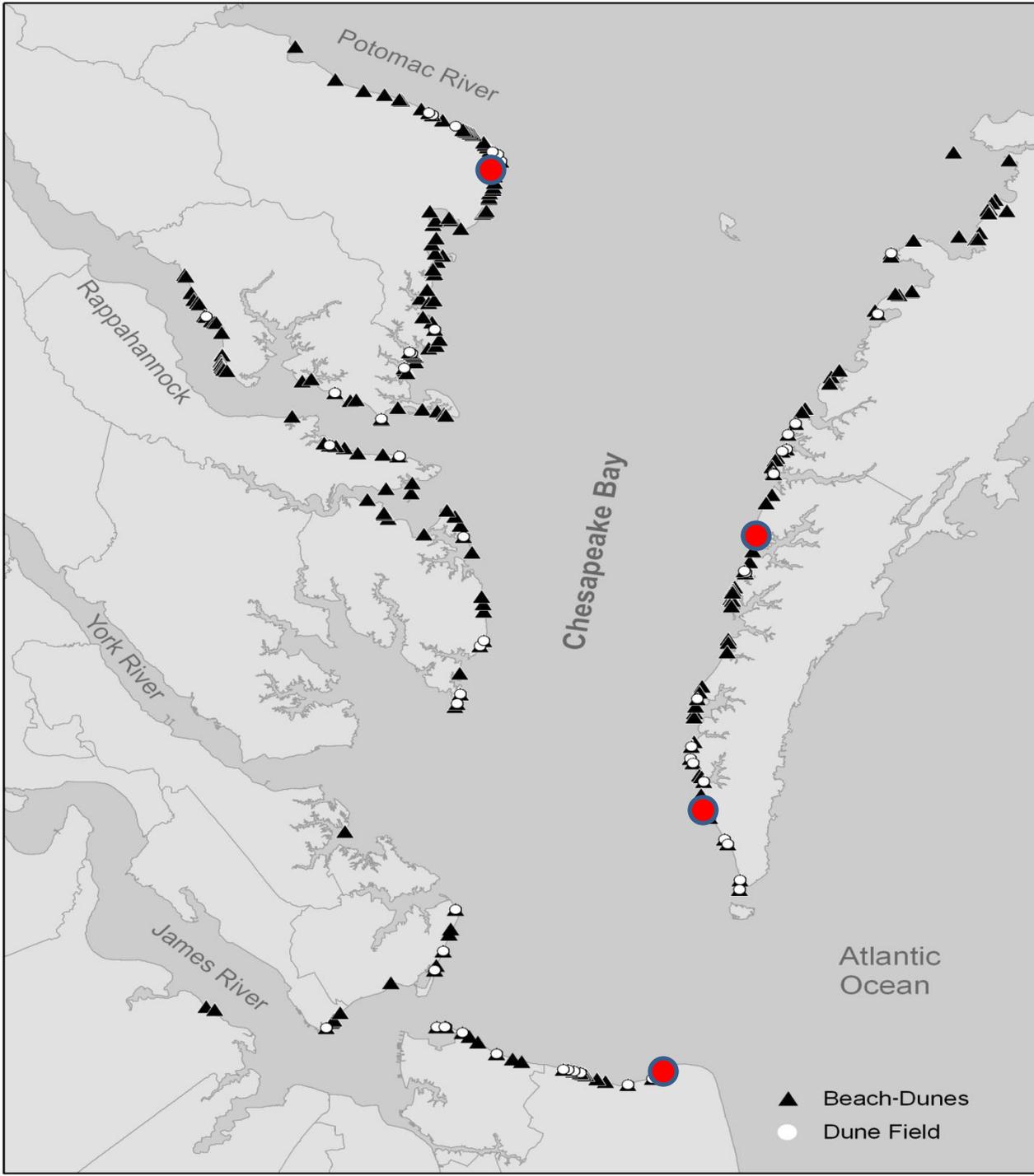
<b>Classification</b>	<b>Classification Category</b>	<b>N</b>	<b>Mean EDI</b>	<b>Mean Standard Error</b>
<b>Natural</b>		111	0.103	0.0033
	<b>Man-Influenced</b>	114	0.113	0.0036
Fetch Exposure	Riverine, Bay influenced	39	0.105	0.0070
	Open Bay	145	0.109	0.0031
	Riverine	44	0.104	0.0042
Shore Orientation	North	30	0.109	0.0066
	Northeast	47	0.117	0.0065
	East	37	0.099	0.0056
	Southeast	12	0.099	0.0106
	South	12	0.119	0.0158
	Southwest	20	0.108	0.0075
	West	37	0.108	0.0053
	Northwest	33	0.103	0.0047
Secondary Dunes	Present	60	0.106	0.0051
	Absent	168	0.109	0.0028
Morphologic Setting	Pocket	27	0.098	0.0053
	Linear	118	0.114	0.0034
	Shallow Bay	19	0.107	0.0079
	Salient	8	0.078	0.0130
	Creek Mouth Barrier	42	0.100	0.0052
	Spit	14	0.118	0.0140
Geologic Underpinnings	Marshy	107	0.105	0.0034
	Upland	121	0.110	0.0035

Summary of statistical comparisons-A. Parametric tests include the two sample t-test, the ANOVA with the Tukey multiple comparisons test. Non-parametric tests include the Kruskal-Wallis test.

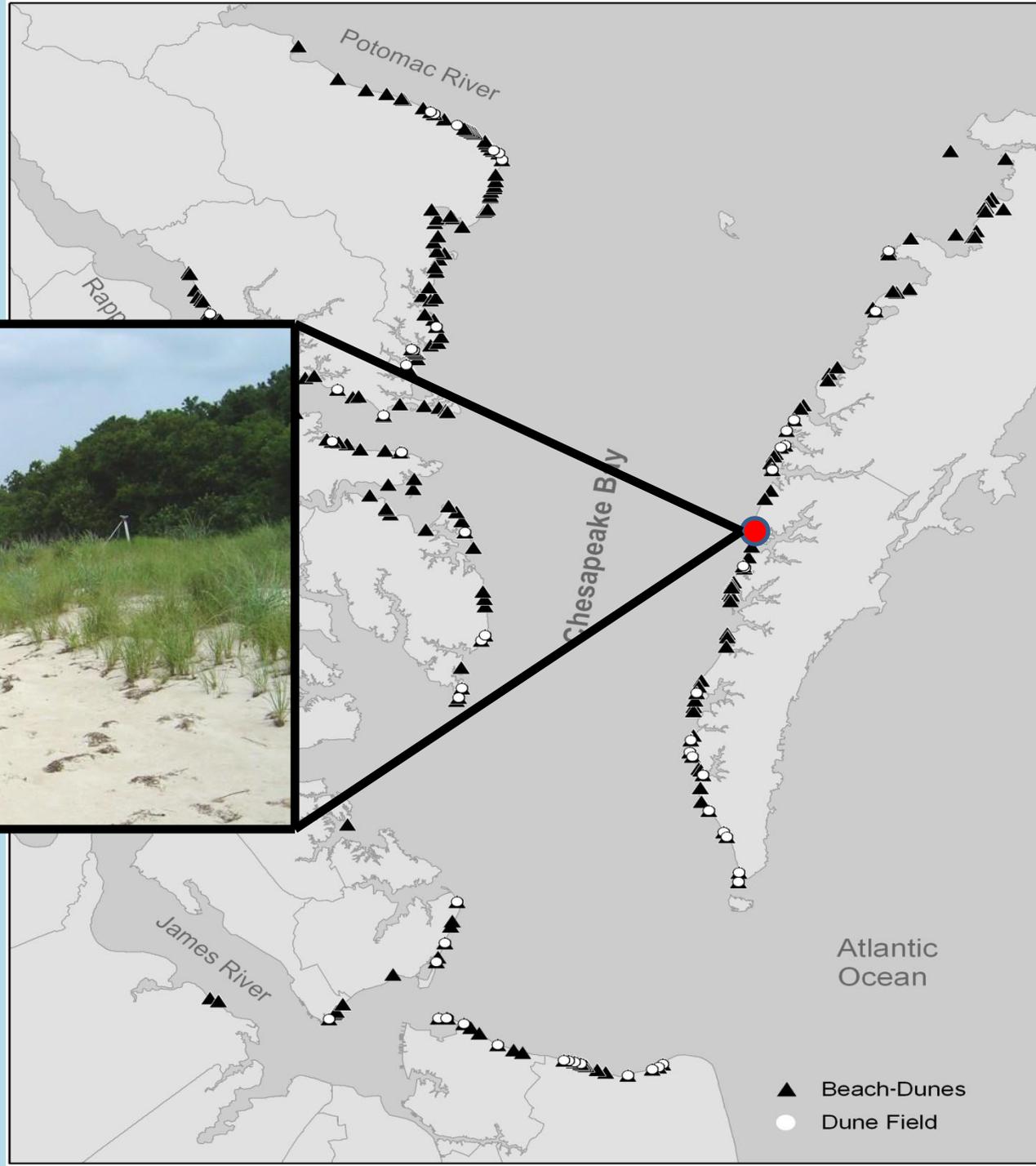
	Parametric	Non-parametric
Index vs fetch exposure	nsd	nsd
Index vs shore orientation	nsd	nsd
natural vs man-influenced	sd*	nsd
Index vs morphologic setting	SD**	SD
Index vs Secondary dunes	nsd	nsd
Index vs geologic underpinnings	nsd	nsd

\* This is considered an artifact of the large sample size since the power is only about 0.53. Also, when obvious outliers are removed the result is no significant difference (**P-Value = 0.171**)

\*\* The P-value for the ANOVA is 0.017, which shows significant differences somewhere in the data set. However, results of the Tukey tests turned up negative. Analysis of the 95% CIs from the pooled StDev shows that difference may occur between linear and salient systems.

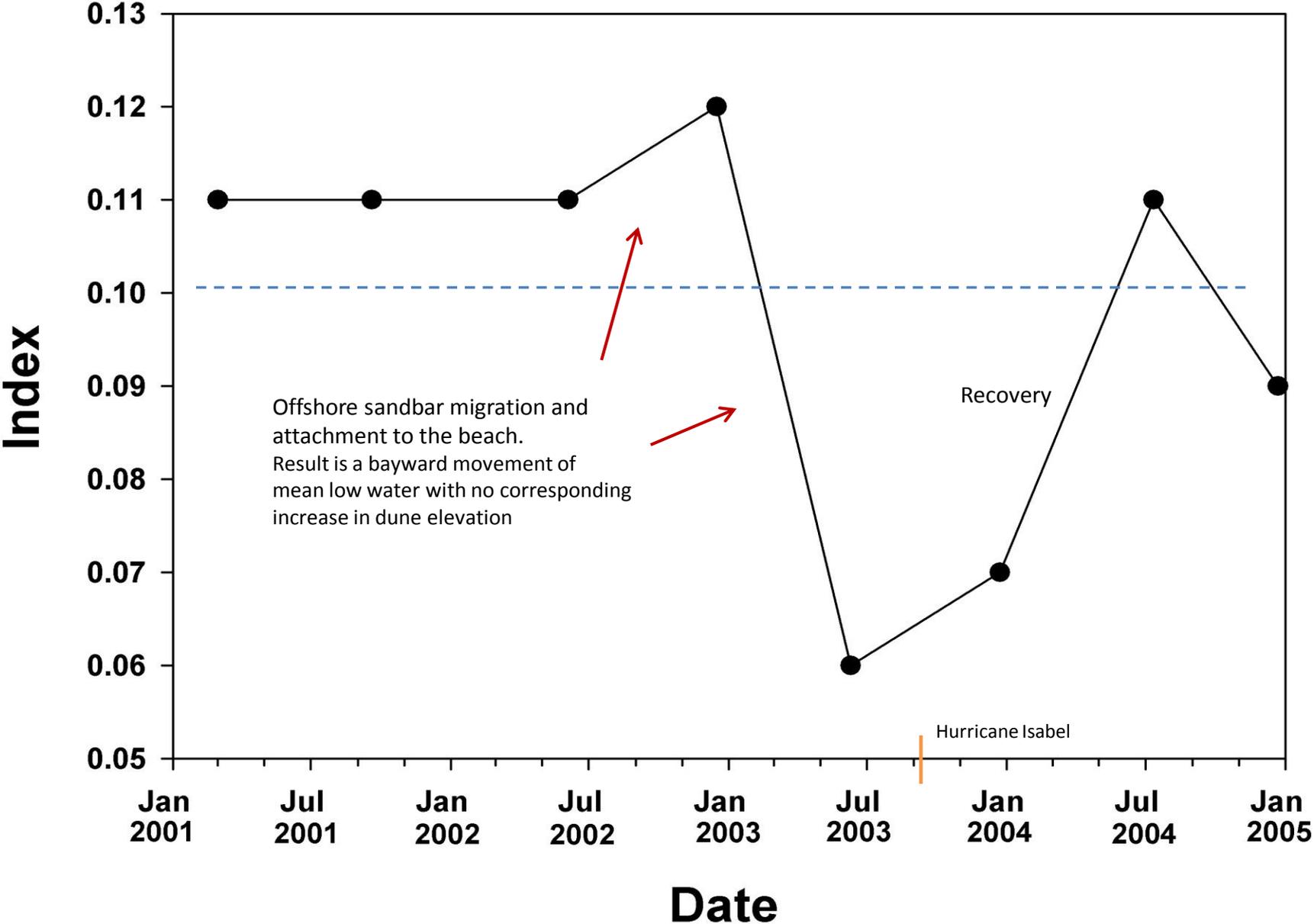


Linear, Open Bay, West Facing

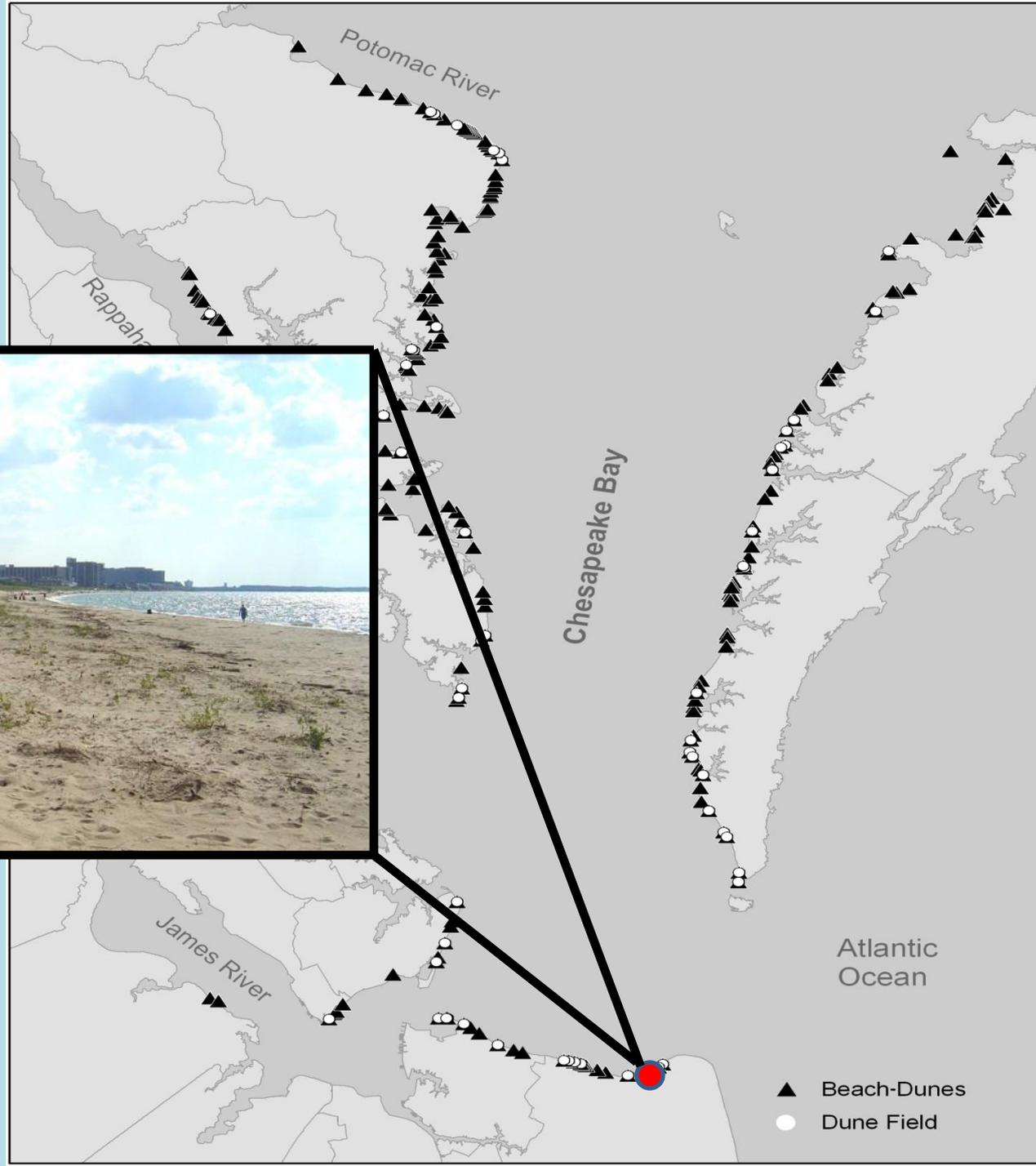


- ▲ Beach-Dunes
- Dune Field

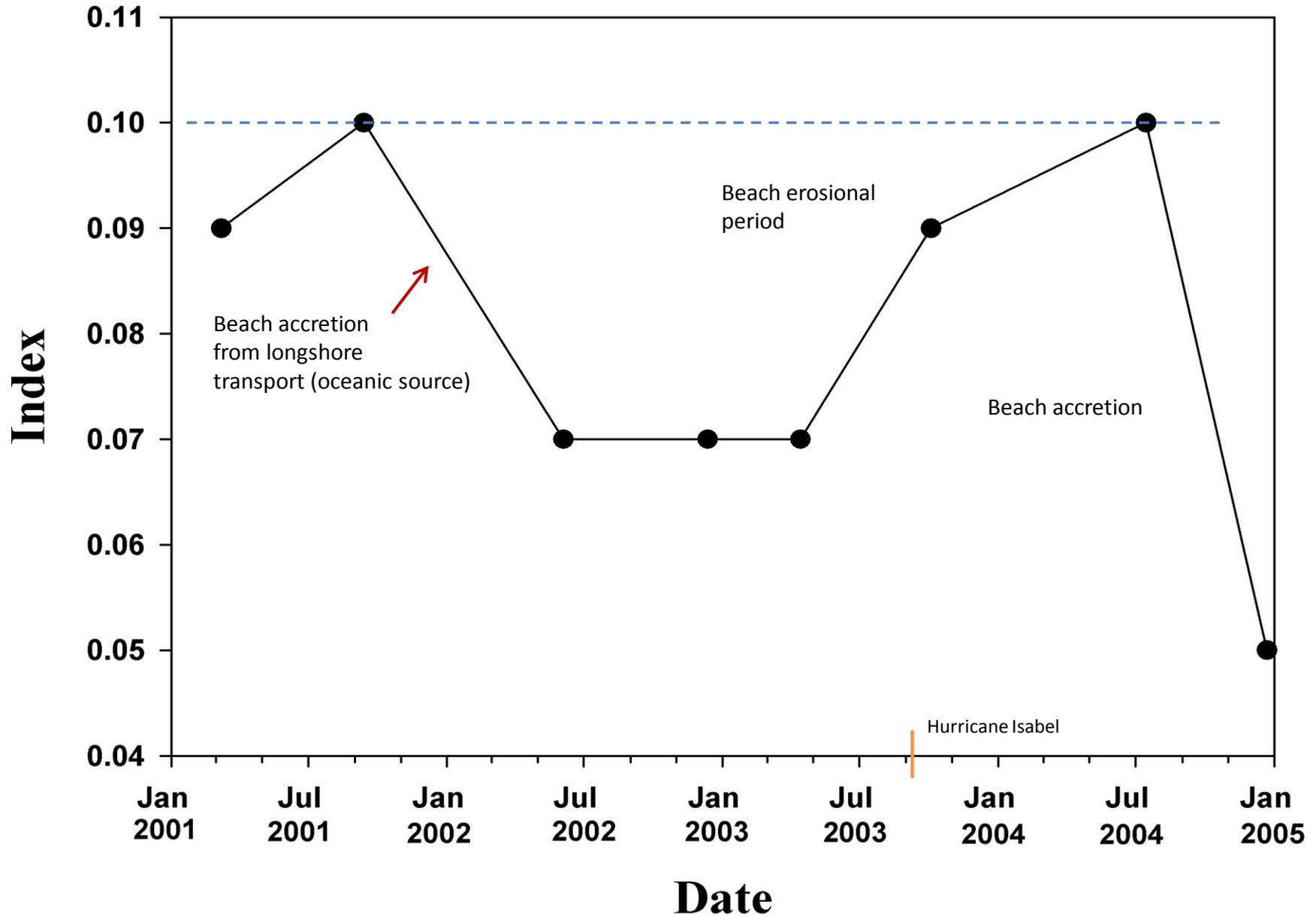
# Linear, Open Bay, West Facing

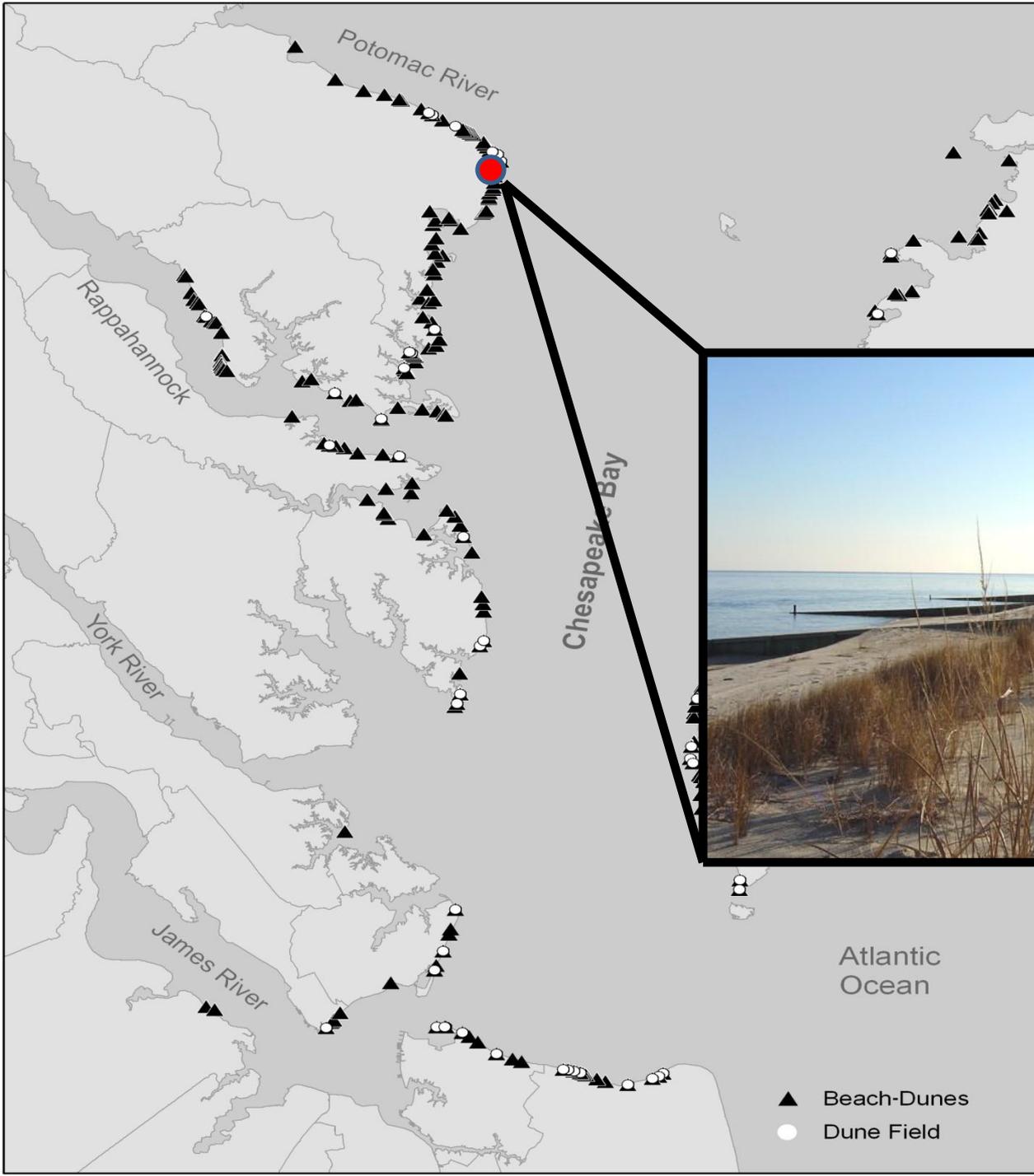


Linear, Open Bay,  
Northwest Facing



# Linear, Open Bay, Northwest Facing

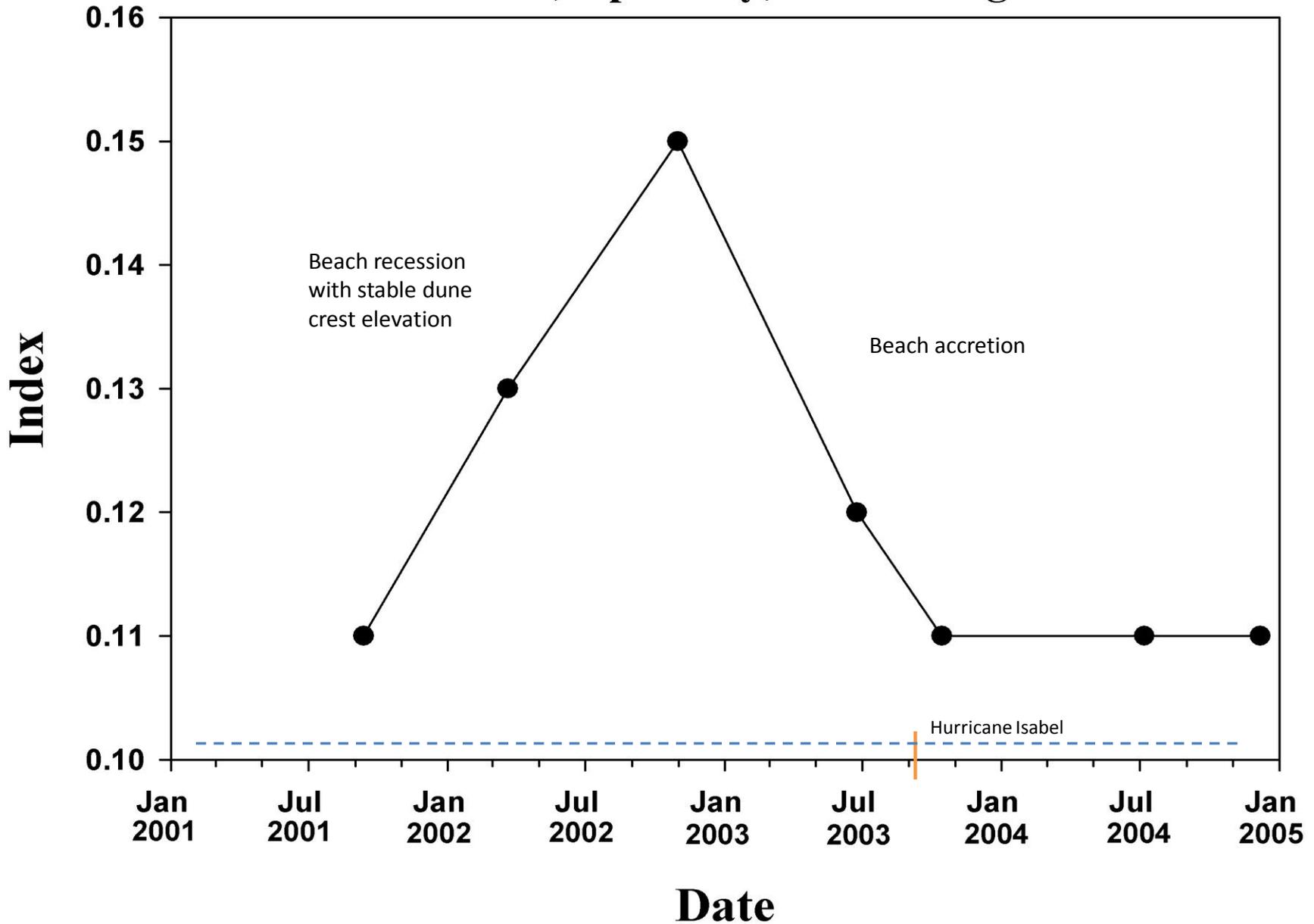




Linear, Open Bay, East Facing



# Linear, Open Bay, East Facing

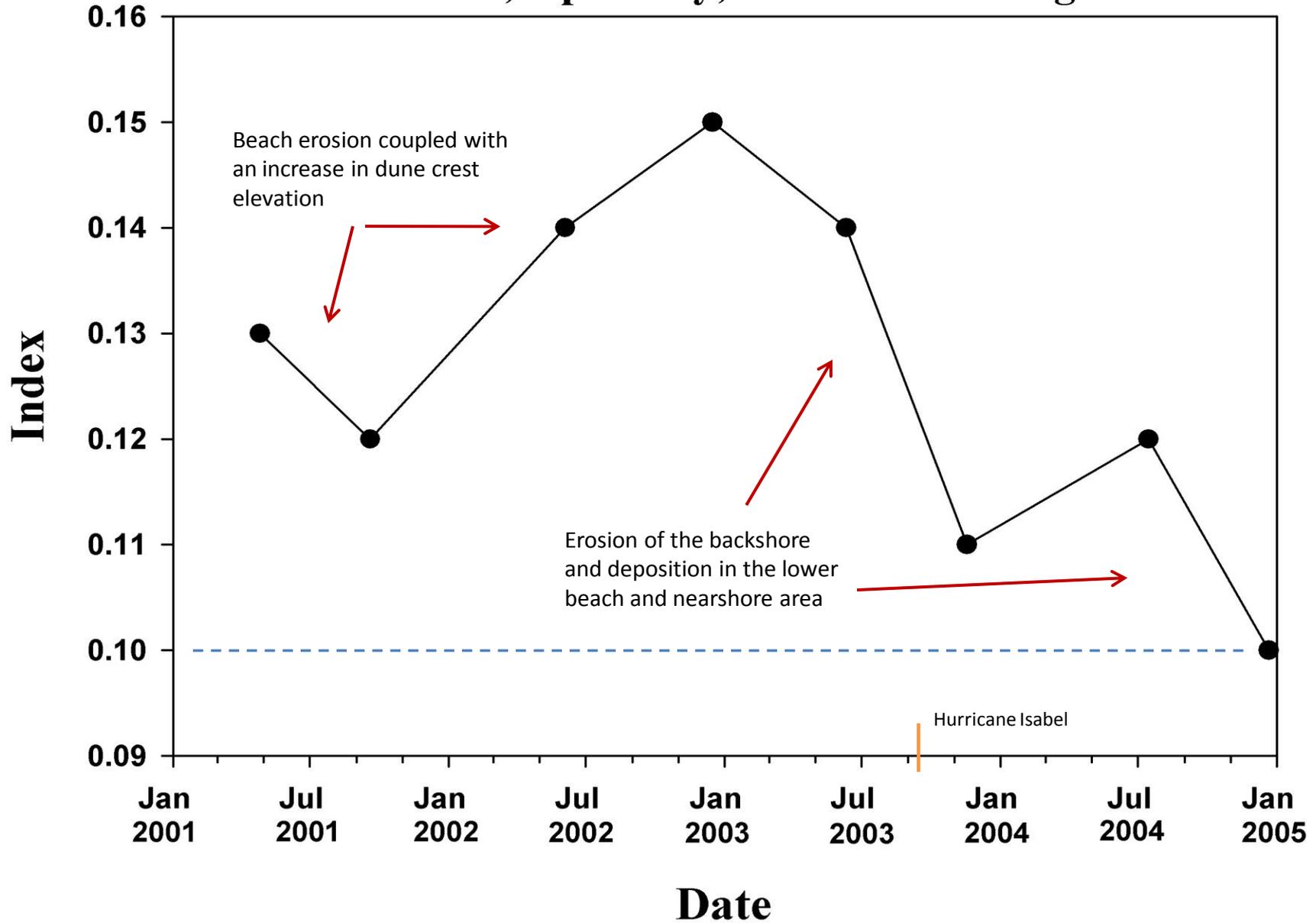


Linear, Open Bay,  
Southwest Facing

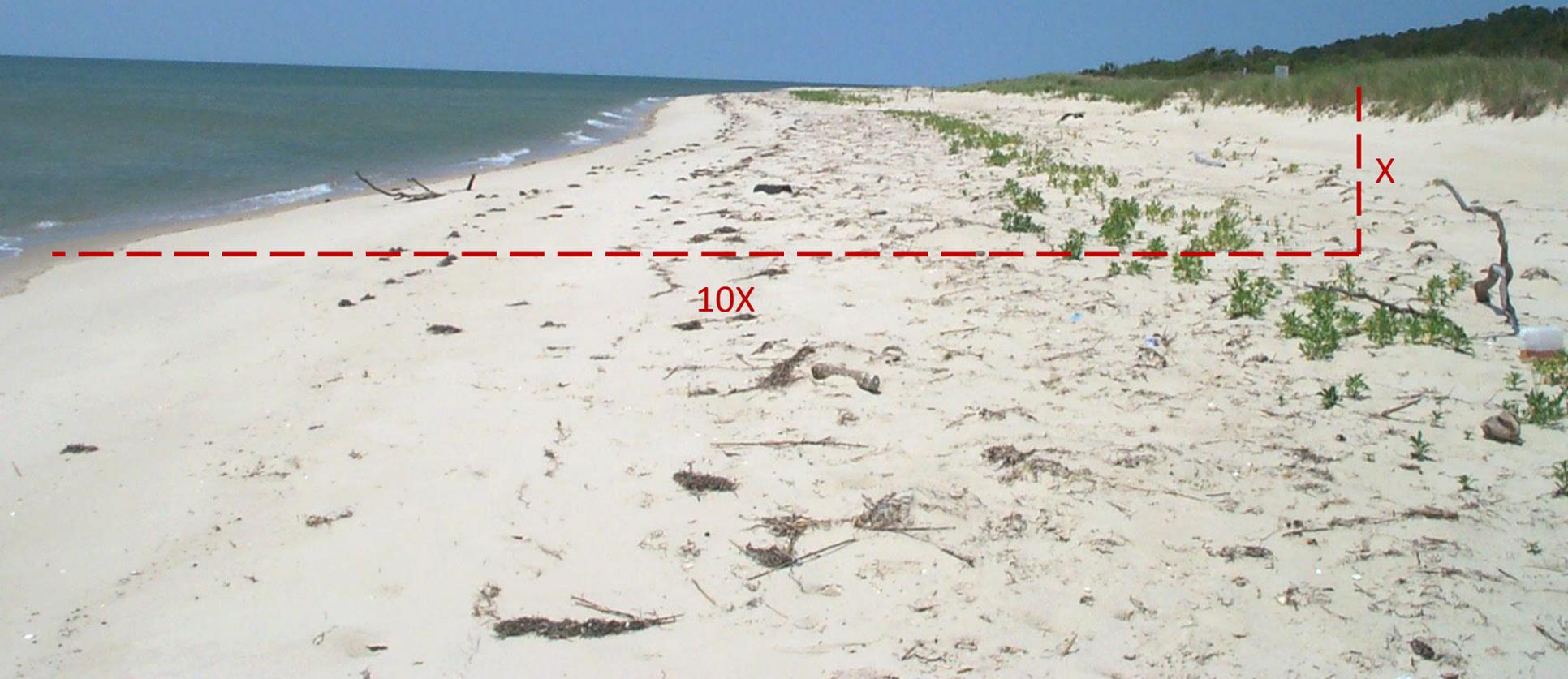


- ▲ Beach-Dunes
- Dune Field

# Linear, Open Bay, Southwest Facing



# “Point One Rule”



10X

X



**So What ?**

# Shoreline Assessments

degree of impact

proximity to equilibrium

where recovery will occur





# **Beach Nourishment/Dune Creation**

- sustainable design specs**
- accurate estimates of sand required**

0.?



**Thank you.**

**Questions or Comments?**

