Monitoring Habitat Change

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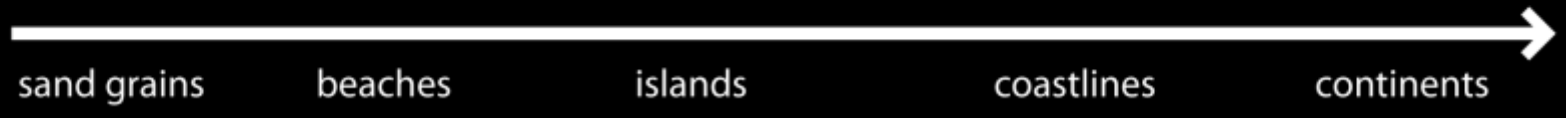
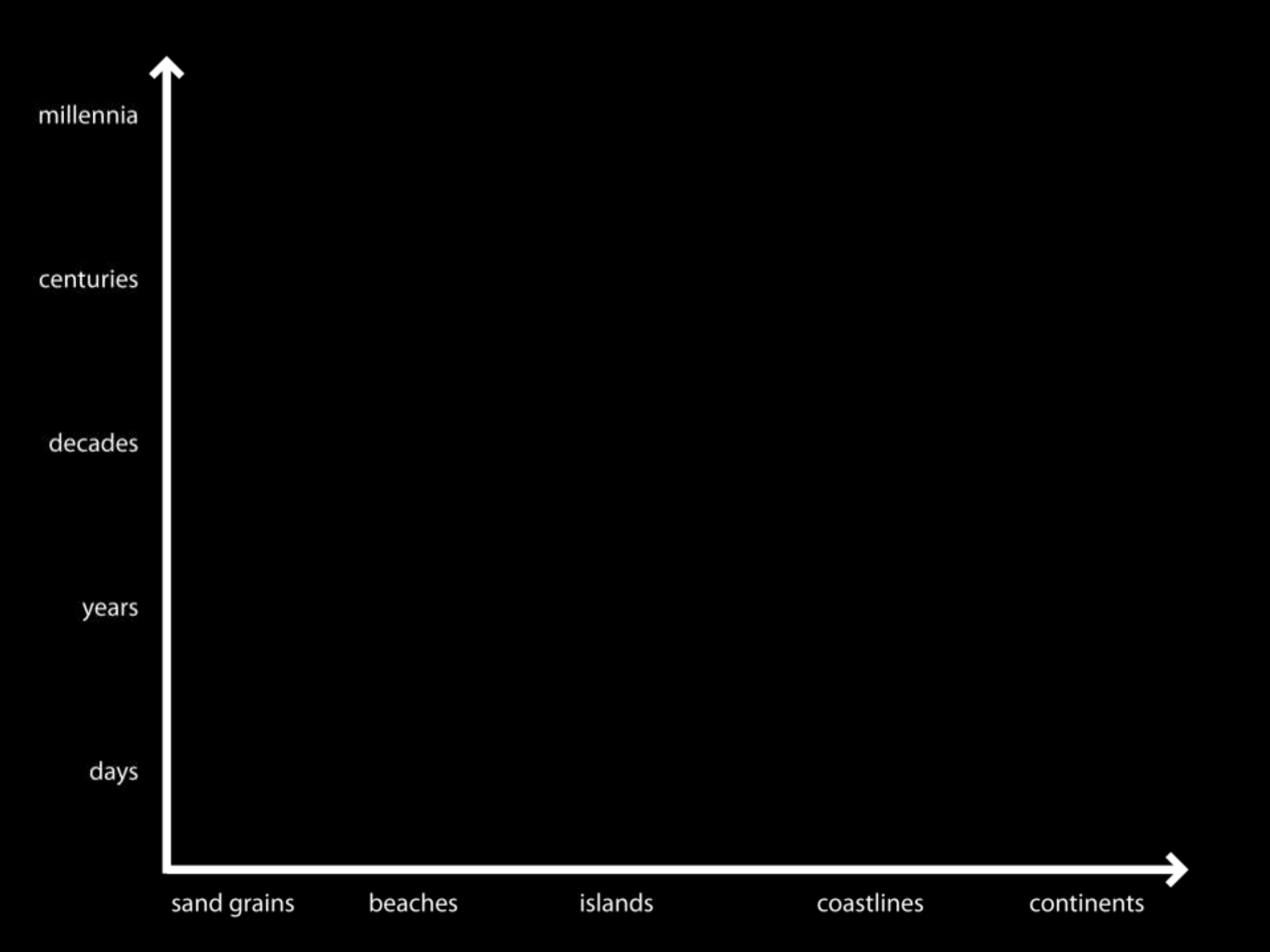
Ocean and Coastal Observing Workshop
Havana, Cuba, July 8, 2017


sand grains
beaches
islands
coastlines
continents


millennia
centuries
decades
years
days
sand grains
beaches
islands
coastlines
continents

millennia

centuries

decades

years

days

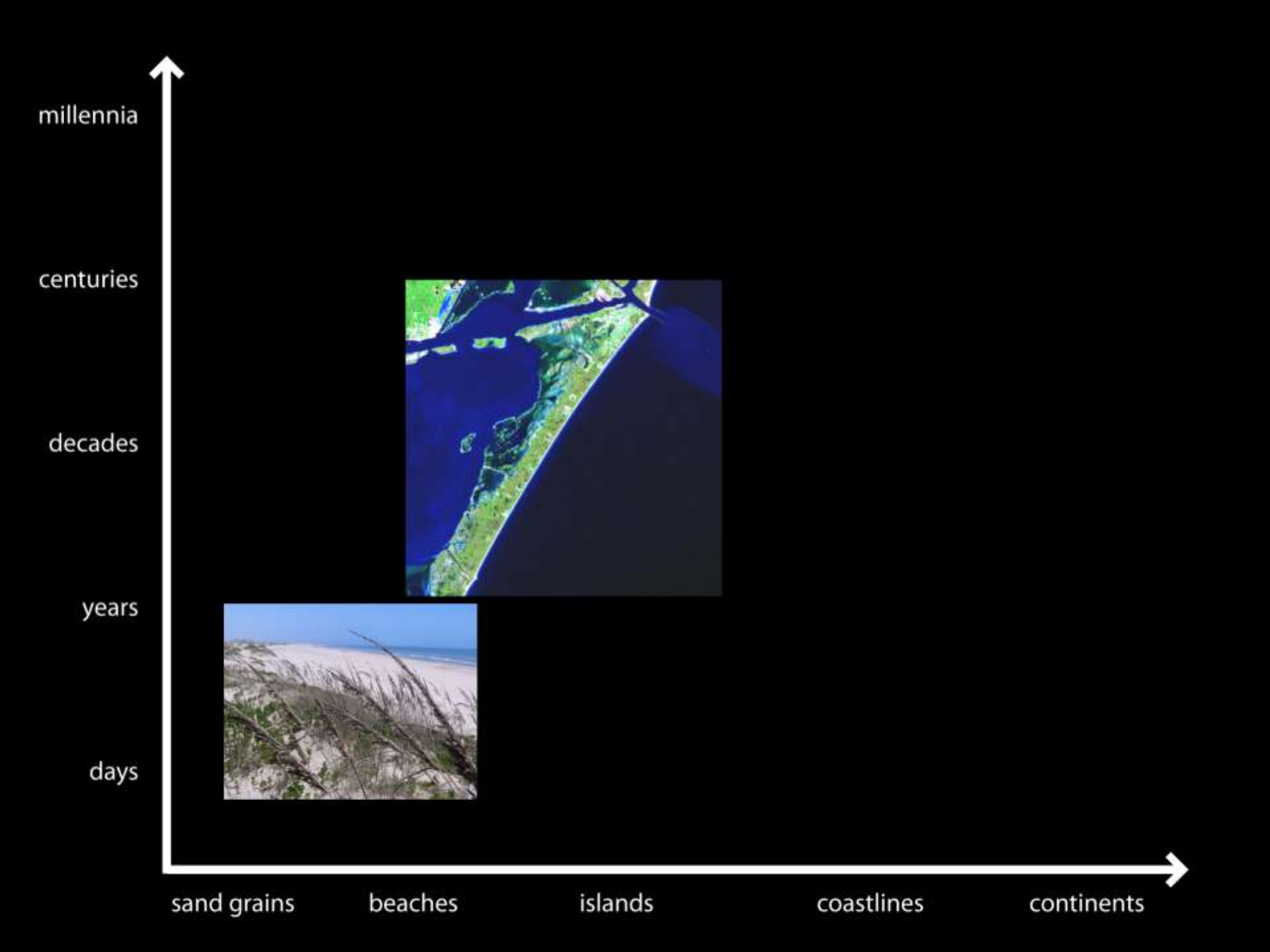
sand grains

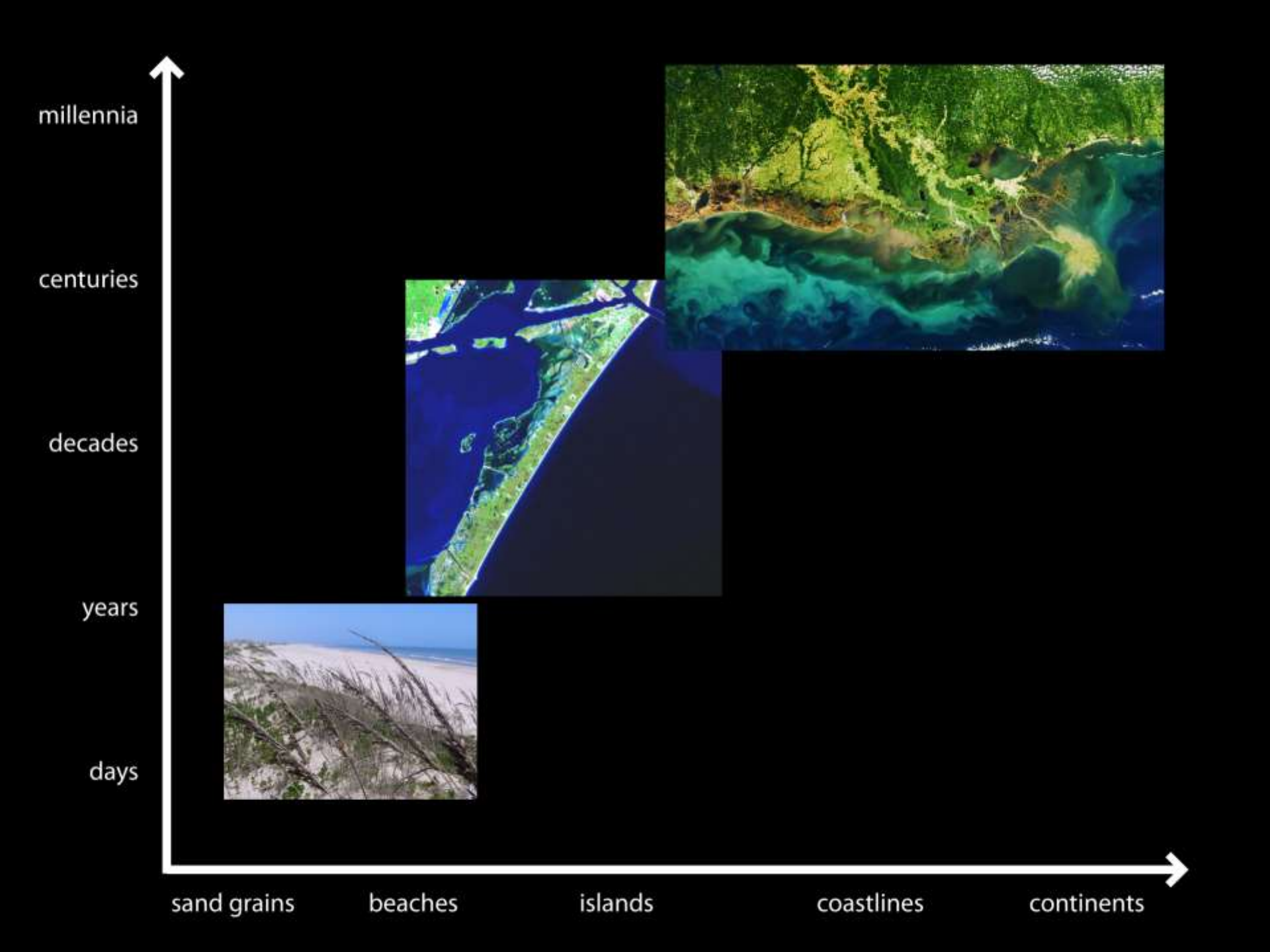
beaches

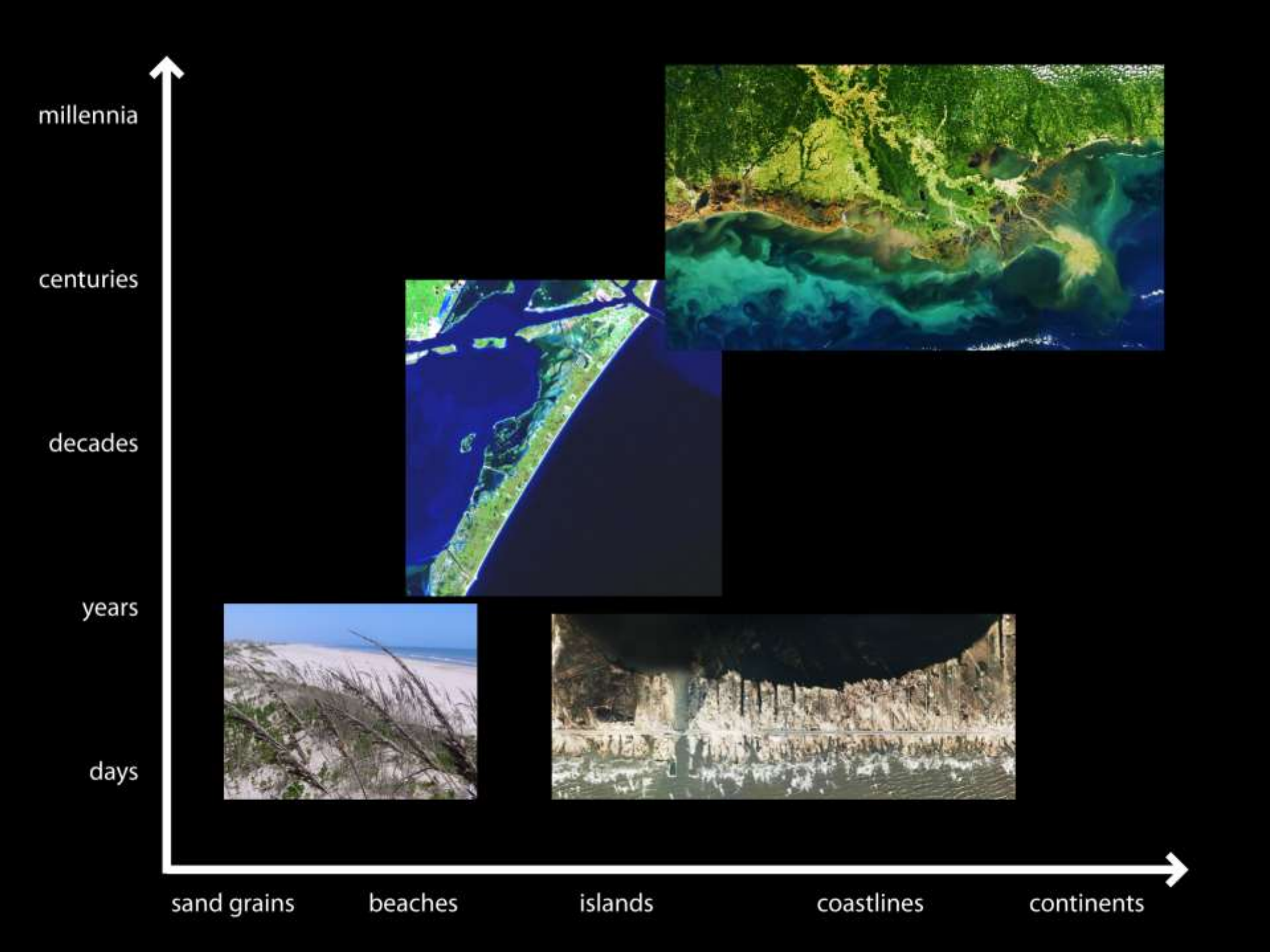
islands

coastlines

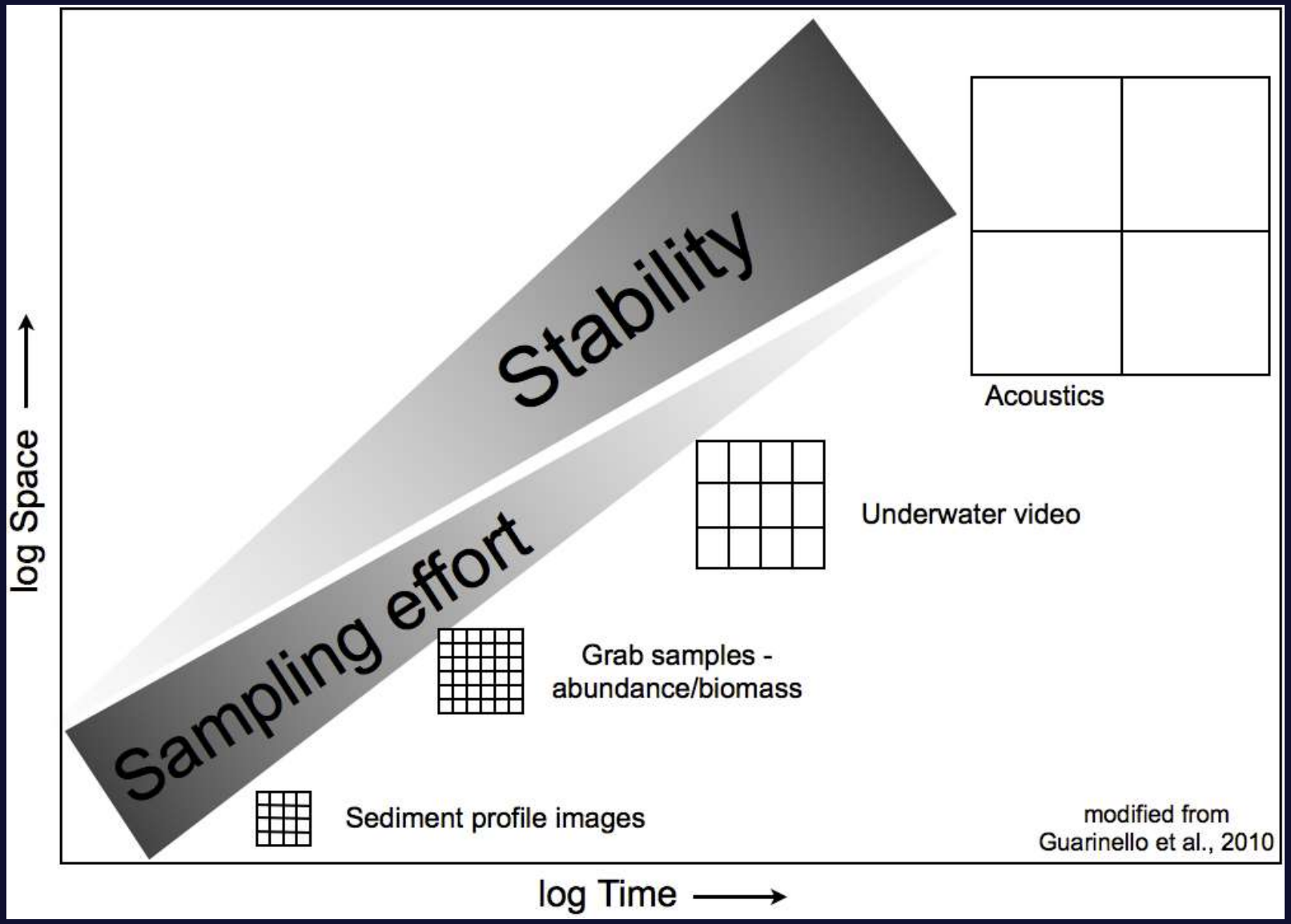
continents


millennia
centuries
decades
years
days
sand grains
beaches
islands
coastlines
continents


millennia
centuries
decades
years
days
sand grains
beaches
islands
coastlines
continents


millennia
centuries
decades
years
days
sand grains
beaches
islands
coastlines
continents

Impact of Variability on Sampling



From: FGDC-STD-018-2012

Habitat Classification Standards

- Structured vocabulary for data and information exchange

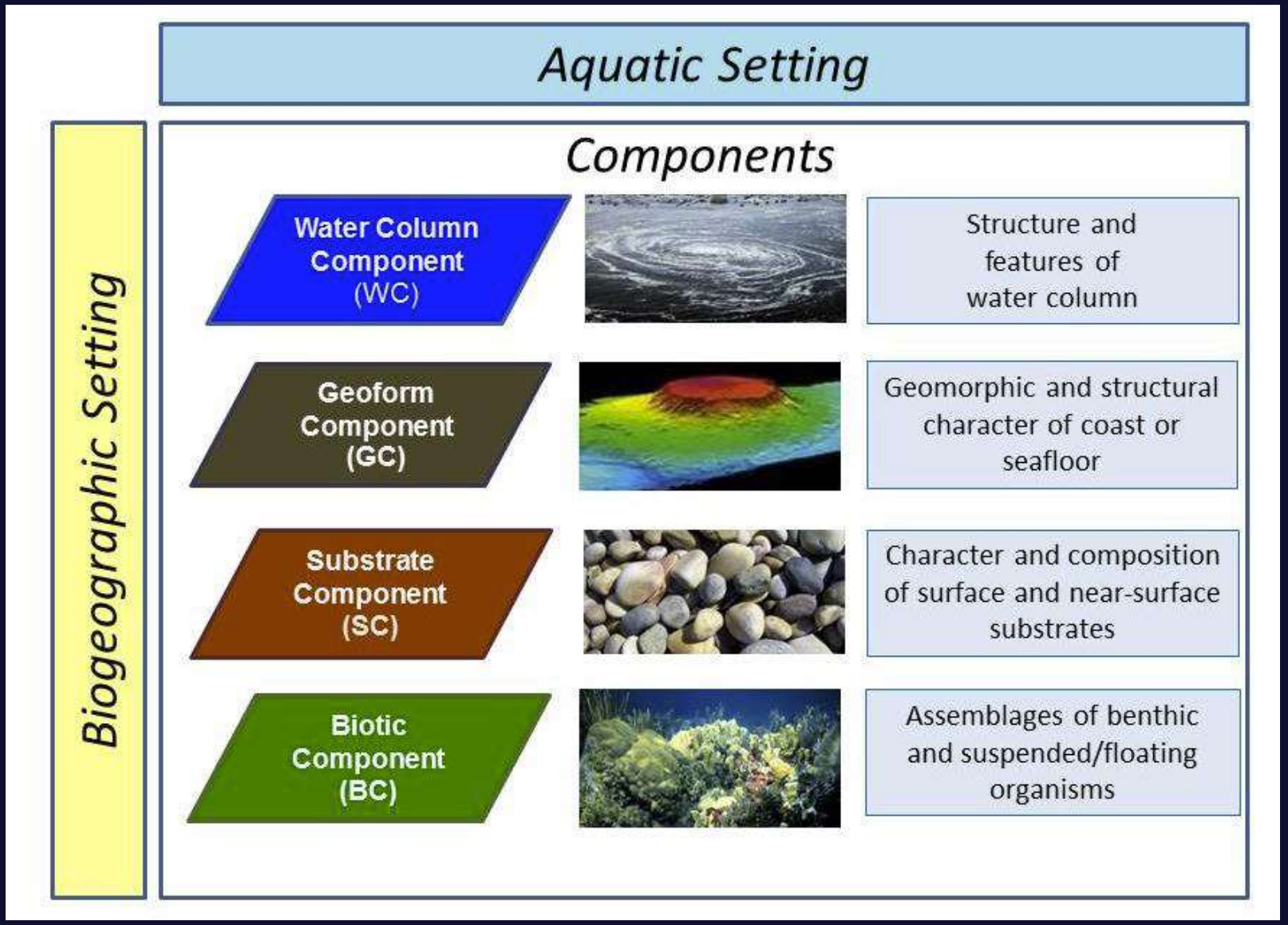
- Facilitates habitat characterization and change analysis across projects, researchers, and nations

CMECS

Coastal and Marine Ecological Classification Standard

- Developed by representatives from U.S. federal and state governments, academia, and NGOs
- Became U.S. federal standard in 2012
- Designed to be interdisciplinary, span spatial and temporal scales, flexible, and expandable

CMECS Framework



From: FGDC-STD-018-2012

Example from Key West

From: FGDC-STD-018-2012

Classification

Biogeographic Setting:

Realm: Tropical Atlantic

Province: Tropical Northwestern Atlantic

Ecoregion: Floridian

Aquatic Setting:

System: Marine

Subsystem: Marine Nearshore

Tidal Zone: Marine Nearshore Subtidal

Classification…

Water Column Component:

Water Column Layer: Marine Nearshore Lower Water Column

Salinity Regime: Euhaline Water

Temperature Regime: Warm Water

Geoform Component:

Tectonic Setting: Passive Continental Margin

Physiographic Setting: Barrier Reef

Geoform Origin: Biogenic

Level 1 Geoform: Shallow/Mesophotic Coral Reef

Level 1 Geoform Type: Patch Coral Reef

Level 2 Geoform: Lagoon

Level 2 Geoform Type: Aggregate Patch Coral Reef

Classification…

Substrate Component:
Substrate Origin: Biogenic Substrate
Substrate Class: Coral Substrate
Substrate Subclass: Coral Reef Substrate
Modifier: Layering: Sand Veneer
Biotic Component:
Biotic Setting: Benthic Biota
Biotic Class: Reef Biota
Biotic Subclass: Shallow/Mesophotic Coral Reef Biota
Biotic Group: Massive Coral Reef
Biotic Community: Massive *Montastraea* Reef

Example from Key West

From: FGDC-STD-018-2012

Data Sharing

Plan → Track → Document → Archive → Disseminate

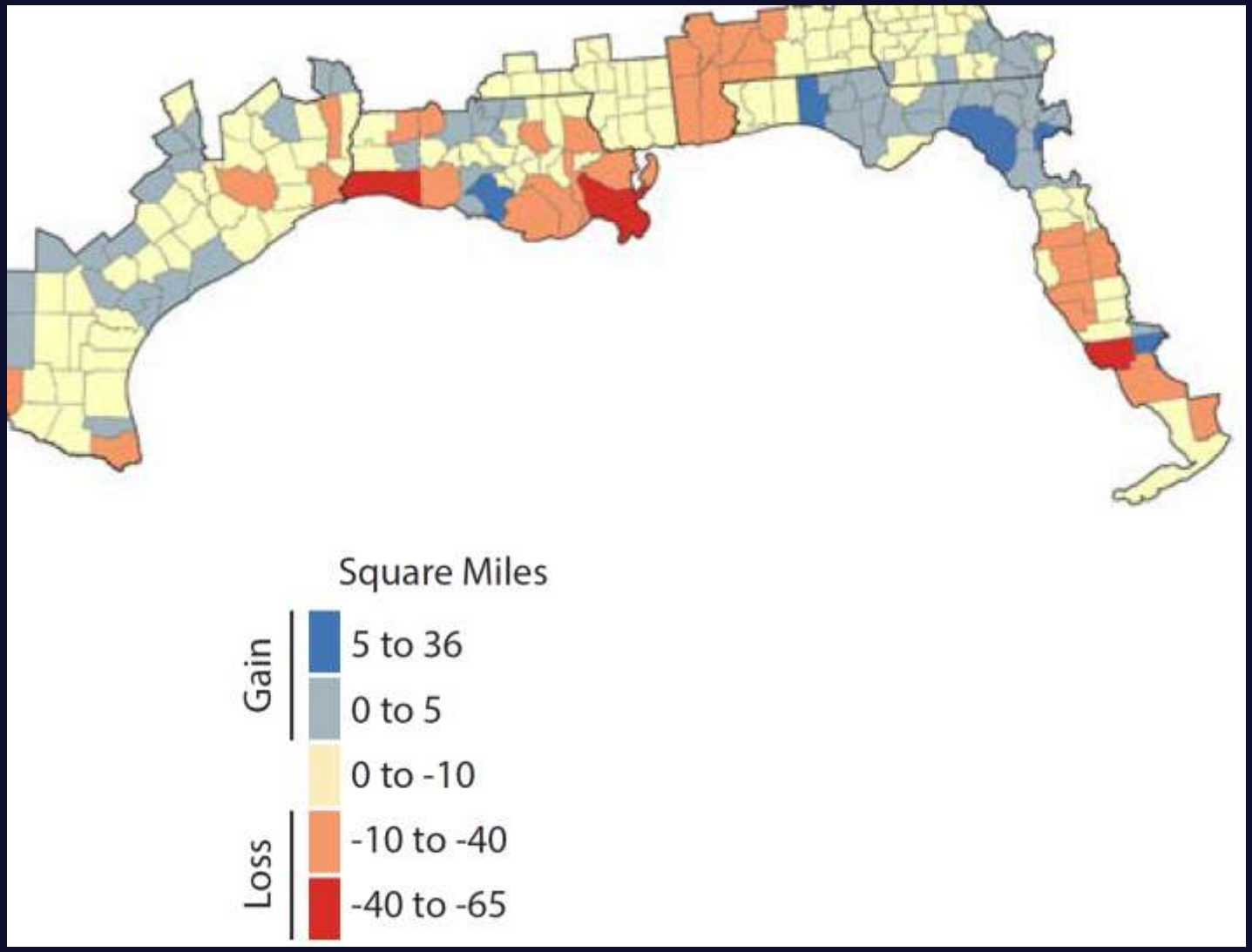
GRIIDC Is a GoMRI Legacy

- Committed to serving GoMRI data until at least 2030
- Expanding services beyond GoMRI-funded research
- Integration with other repositories (e.g., NCEI, DataOne)
- Harte Research Insititute committed to expanding a data sharing culture through GRIIDC

Two Prospects for Gulf-wide Expansion

- Coastal Change Analysis Program (C-CAP)
  - NOAA program since 1990s
  - Landsat (30 m)
  - Standardized classification
  - 5-year intervals
- Shoreline type mapping (Environmental Sensitivity Index (ESI) used for oil spill planning
- Shoreline change analysis programs

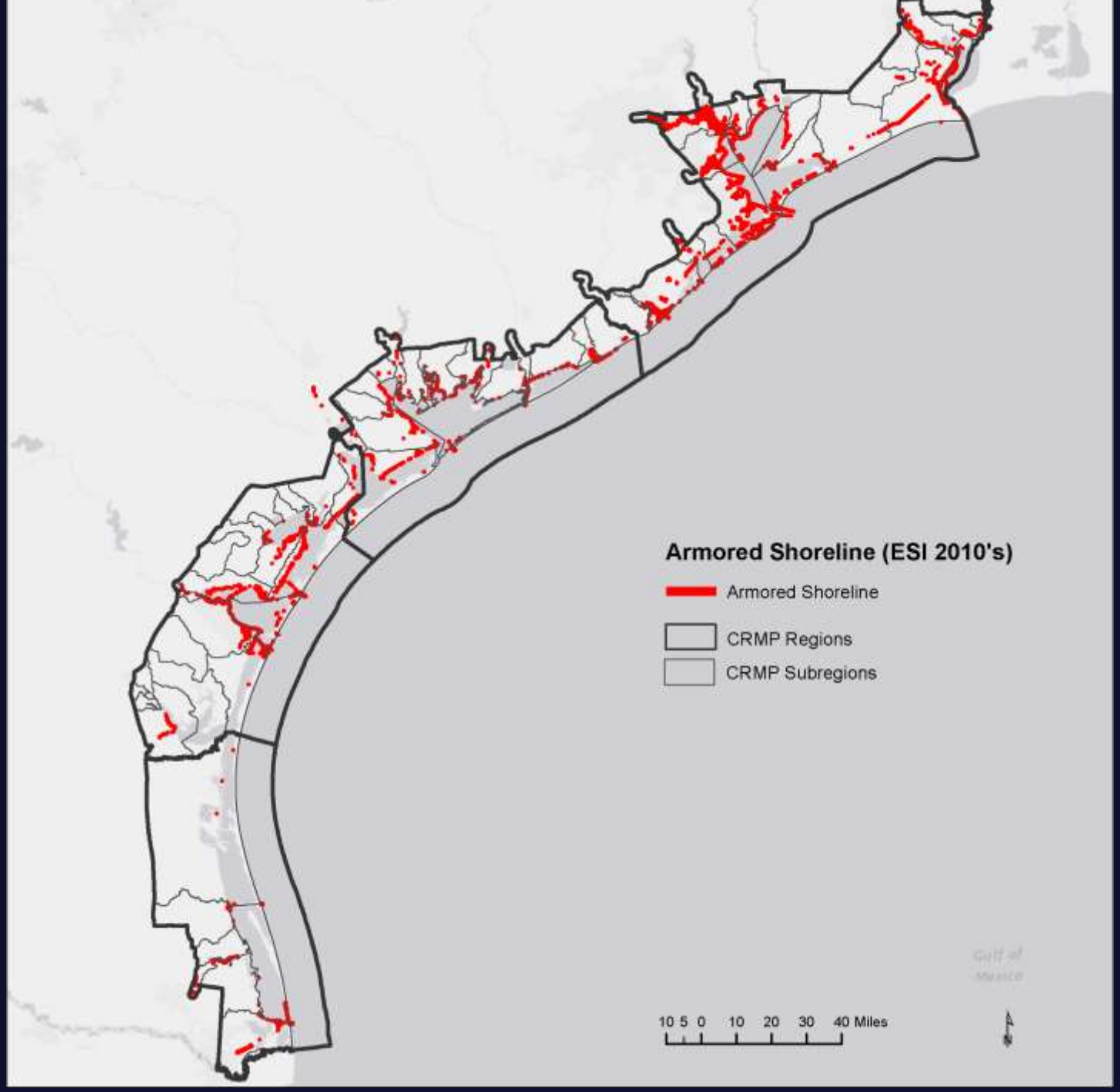
C-CAP Wetland Change 1996 - 2010

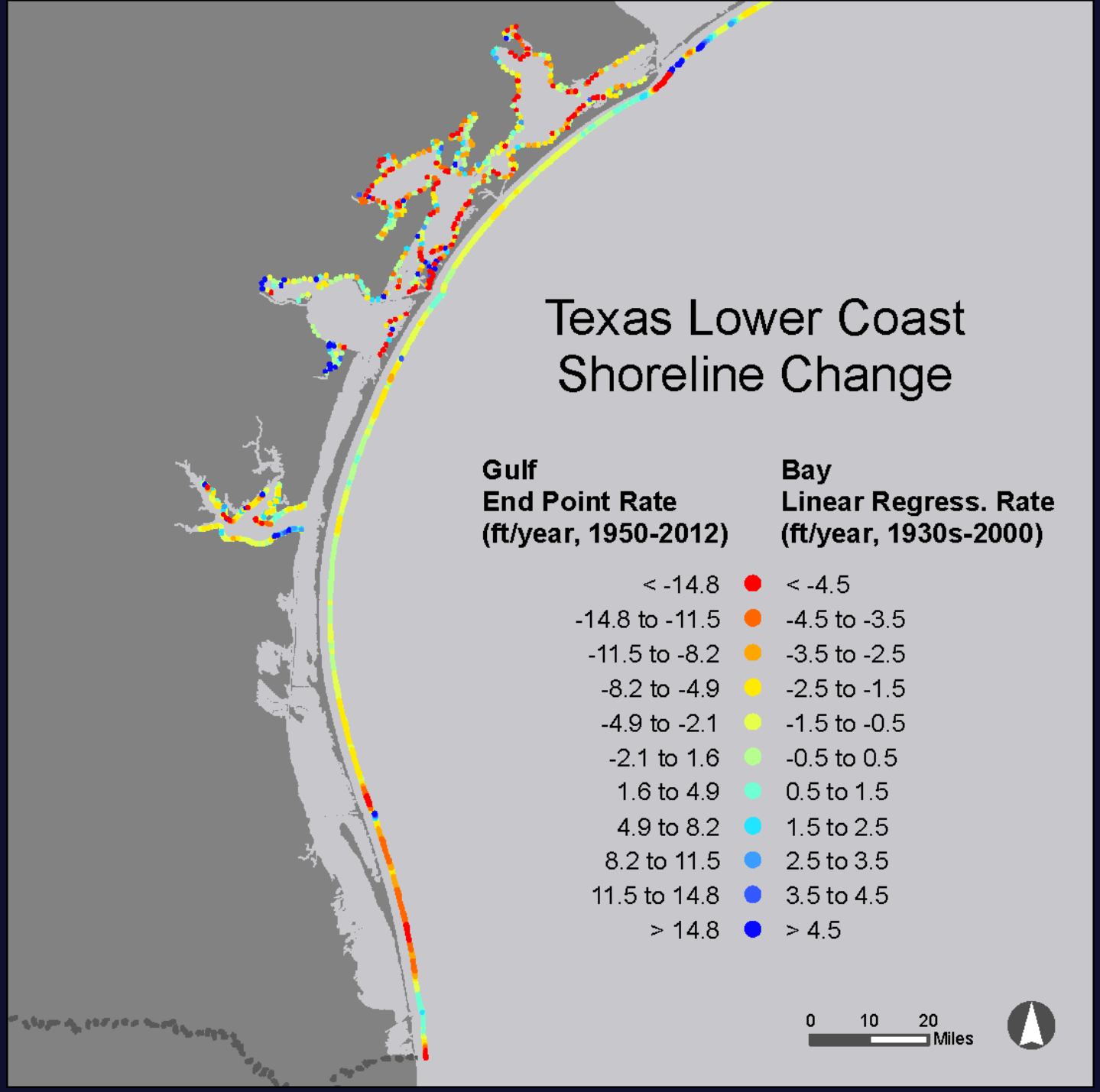


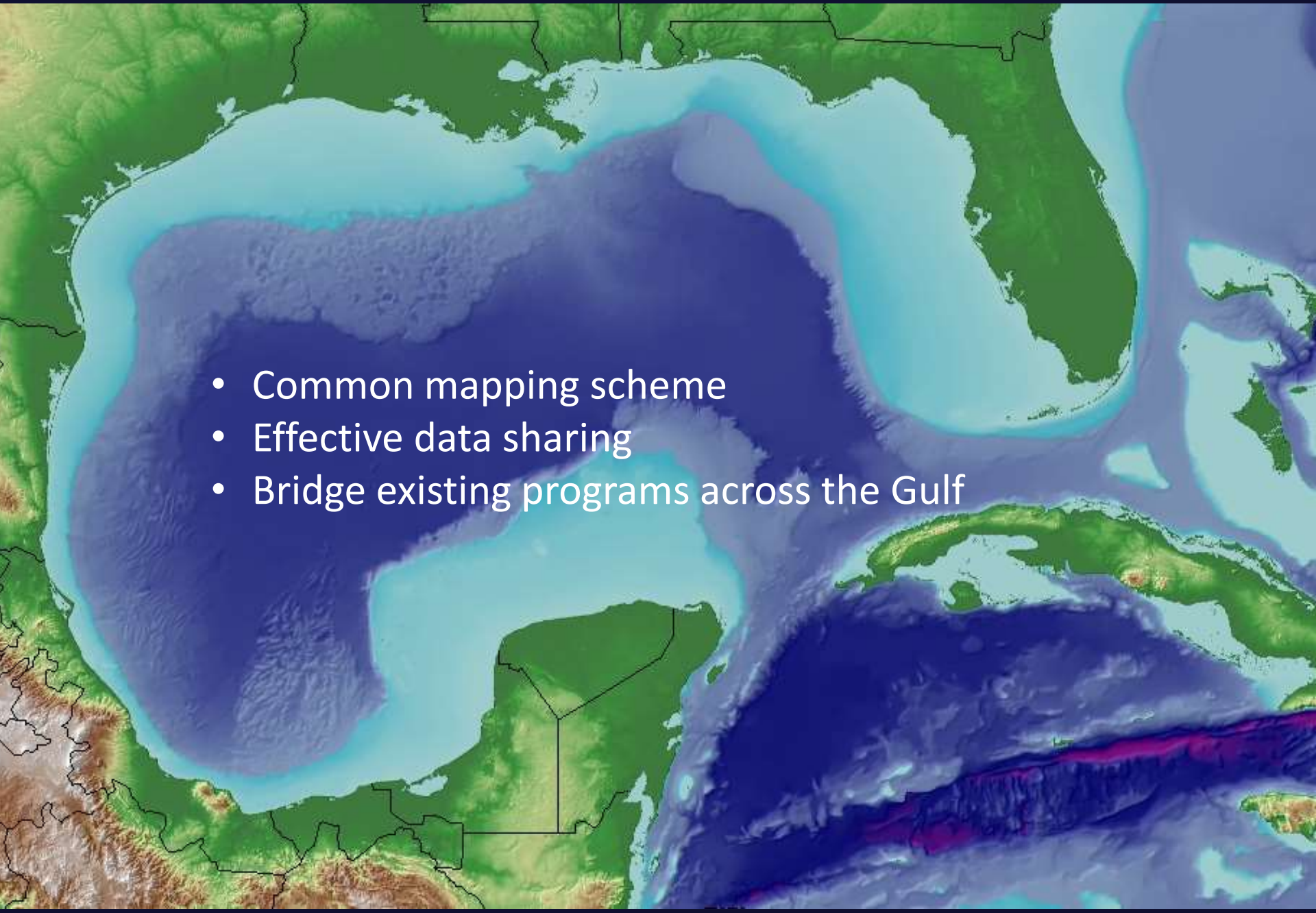
From: Gulf of Mexico Regional Land Cover Change Report 1996- 2010, NOAA

ESI for Shoreline Types

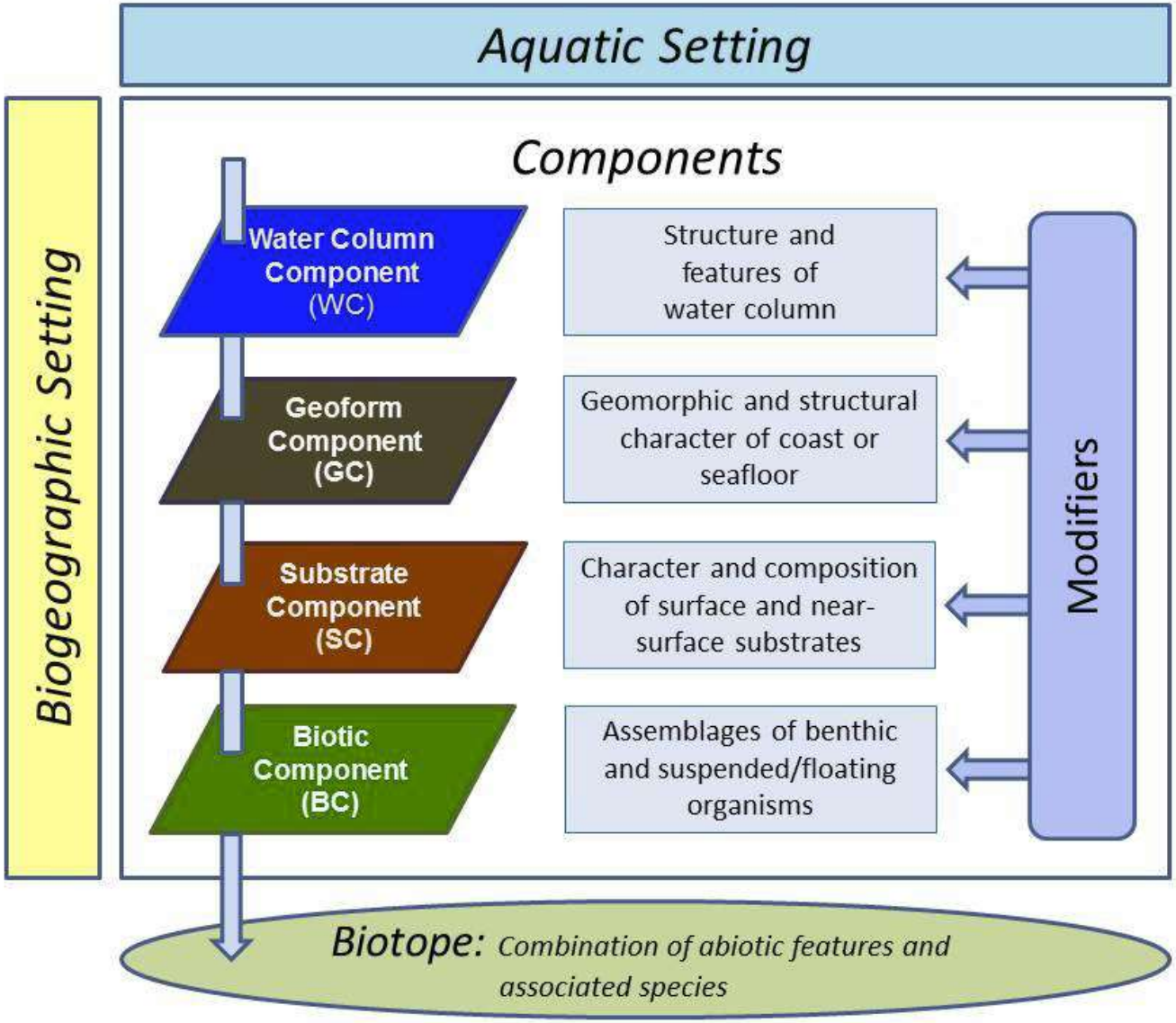
1	Exposed walls and other structures made of concrete, wood, or metal
2A	Scarps and steep slopes in clay
2B	Wave-cut clay platforms
3A	Fine-grained sand beaches
3B	Scarps and steep slopes in sand
4*	Coarse-grained sand beaches
5	Mixed sand and gravel (shell) beaches
6A	Gravel (shell) beaches
6B	Exposed riprap structures
7	Exposed tidal flats
8A	Sheltered solid man-made structures, such as bulkheads and docks
8B	Sheltered riprap structures
8C	Sheltered scarps
9	Sheltered tidal flats
10A	Salt- and brackish-water marshes
10B	Fresh-water marshes (herbaceous vegetation)
10C	Fresh-water swamps (woody vegetation)
1OD	Mangroves


Armored Shoreline (ESI 2010's)
Armored Shoreline
CRMP Regions
CRMP Subregions
10 5 0 10 20 30 40 Miles

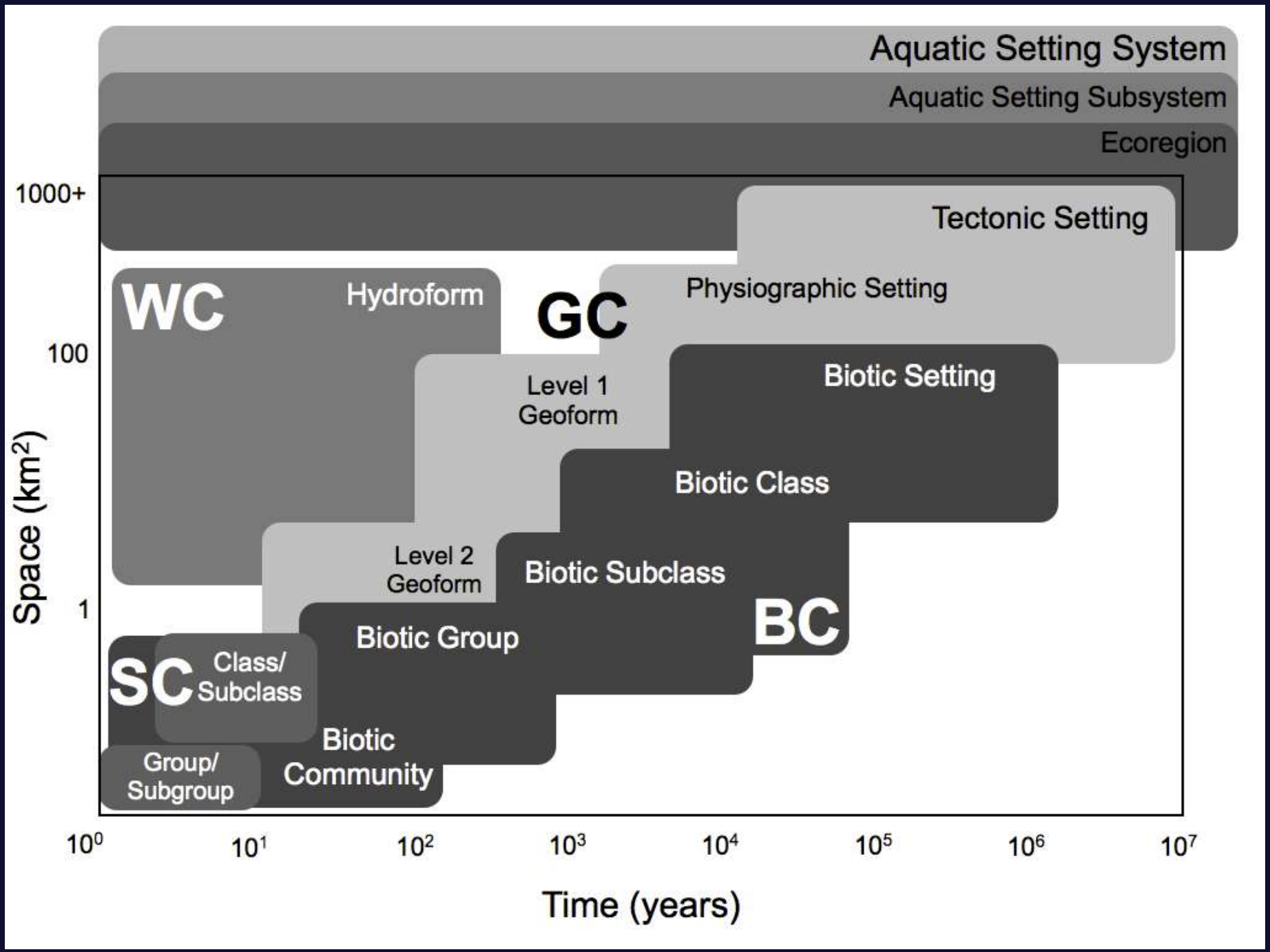

Texas Lower Coast
Shoreline Change
Gulf
End Point Rate
(ft/year, 1950-2012)
Bay
Linear Regress. Rate
(ft/year, 1930s-2000)
< -14.8
-14.8 to -11.5
-11.5 to -8.2
-8.2 to -4.9
-4.9 to -2.1
-2.1 to 1.6
1.6 to 4.9
4.9 to 8.2
8.2 to 11.5
11.5 to 14.8
> 14.8
< -4.5
-4.5 to -3.5
-3.5 to -2.5
-2.5 to -1.5
-1.5 to -0.5
-0.5 to 0.5
0.5 to 1.5
1.5 to 2.5
2.5 to 3.5
3.5 to 4.5
> 4.5
0
10
20
Miles


• Common mapping scheme
• Effective data sharing
• Bridge existing programs across the Gulf

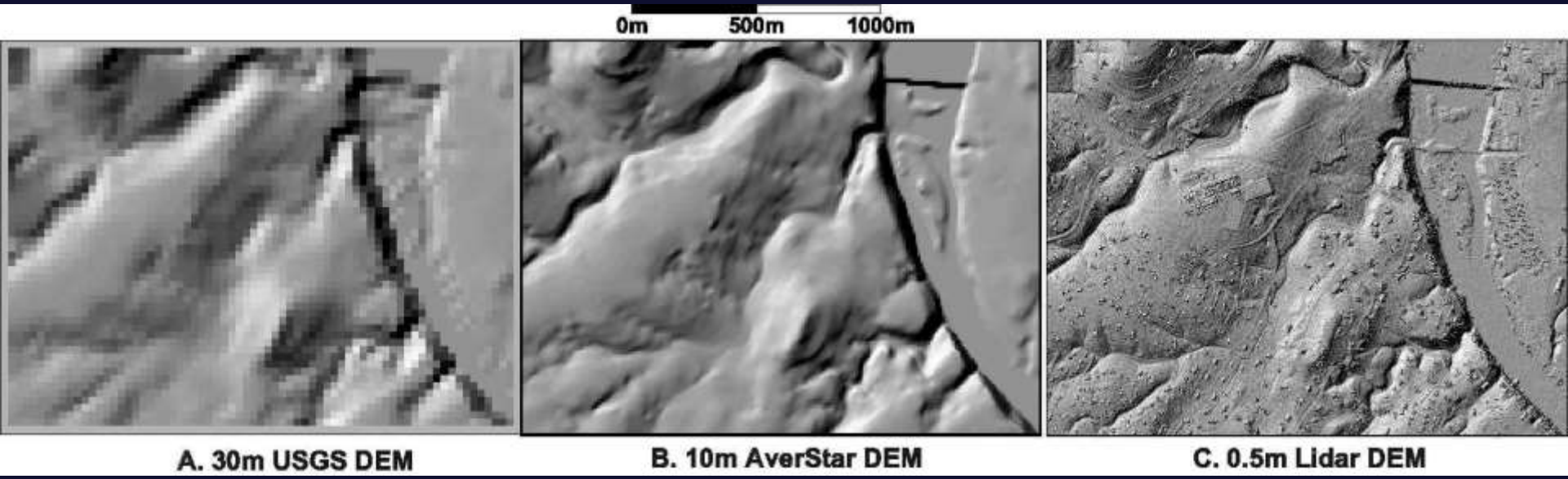
CMECS framework



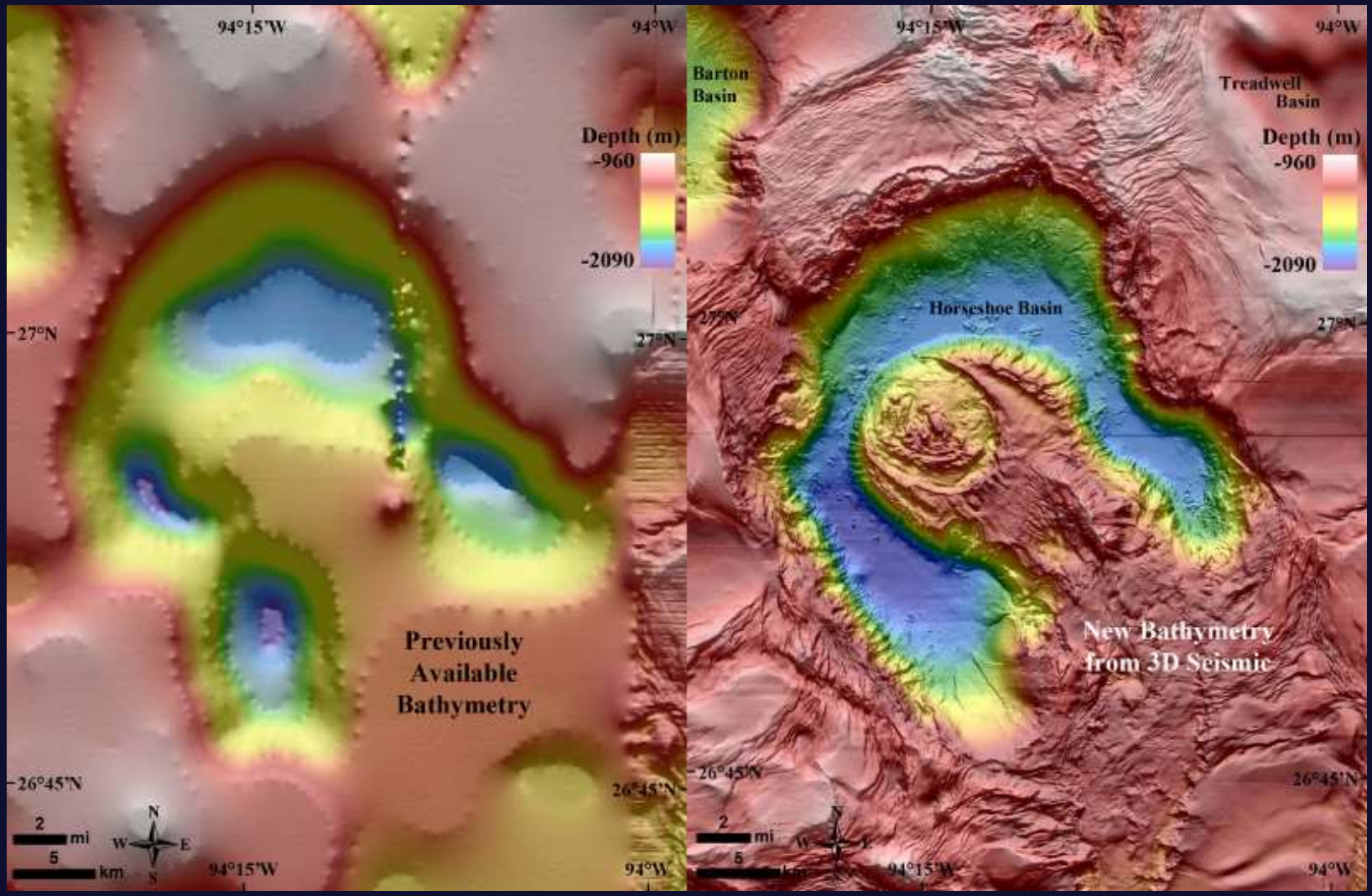
From: FGDC-STD-018-2012


Aquatic Setting System
Aquatic Setting Subsystem
Ecoregion
Tectonic Setting
Physiographic Setting
Hydroform
WC
GC
Level 1 Geoform
Biotic Setting
Biotic Class
Level 2 Geoform
Biotic Subclass
BC
Biotic Group
SC
Class/ Subclass
Biotic Community
Group/ Subgroup
1000+
100
1
Space (km2)
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
Time (years)

Resolution in Time and Space



Resolution in Time and Space



NOAA older bathymetry map

BOEM's new map

Resolution in Time and Space

1-2m

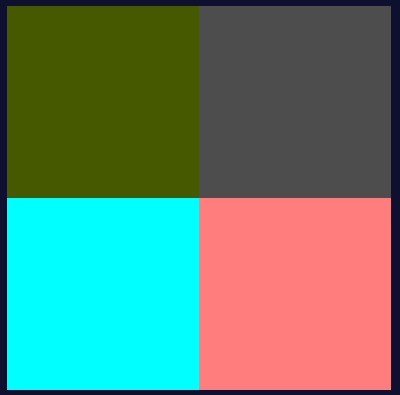
QuickBird, IKONOS

30m

Landsat TM, ETM+

79m

Landsat MSS

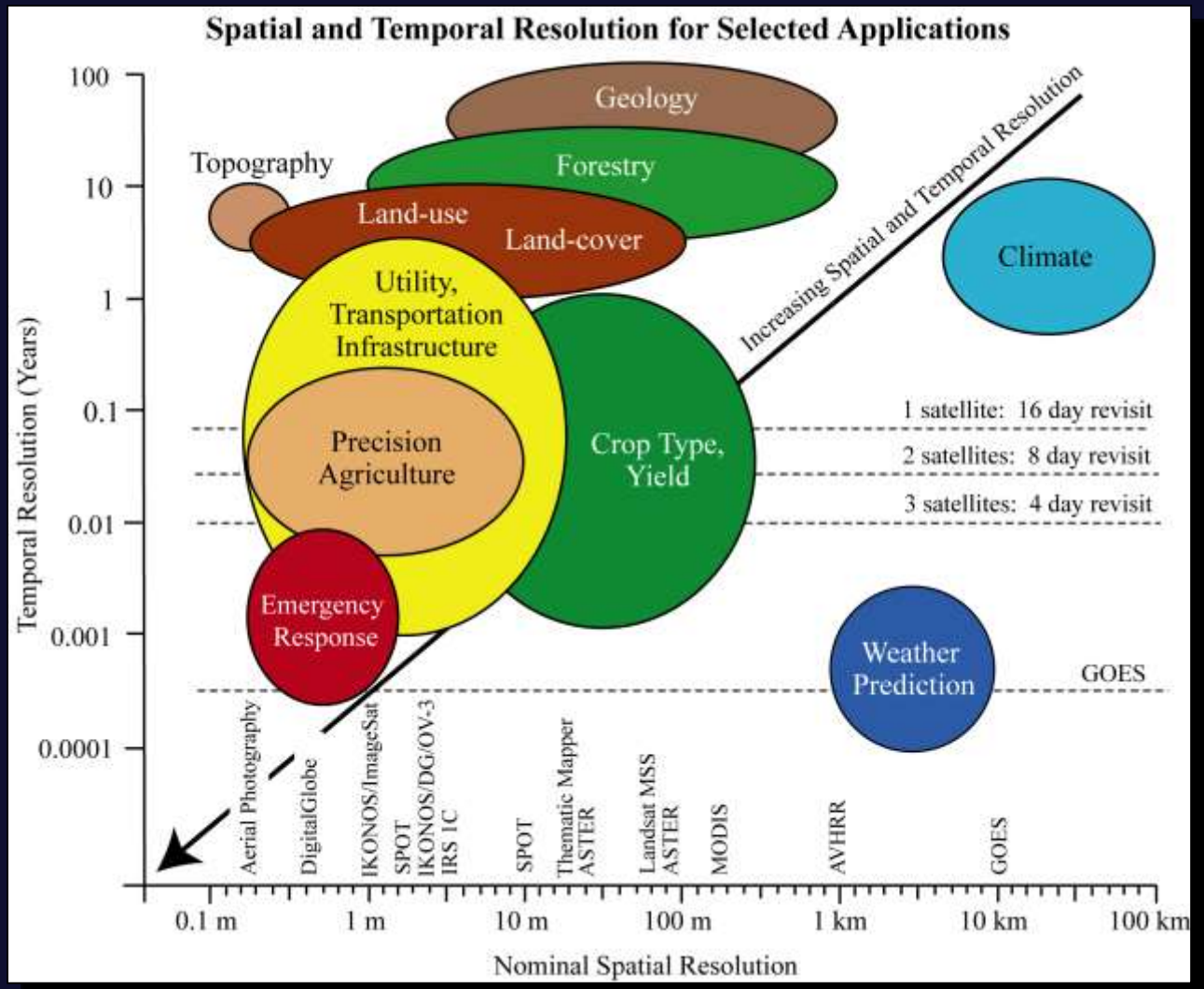


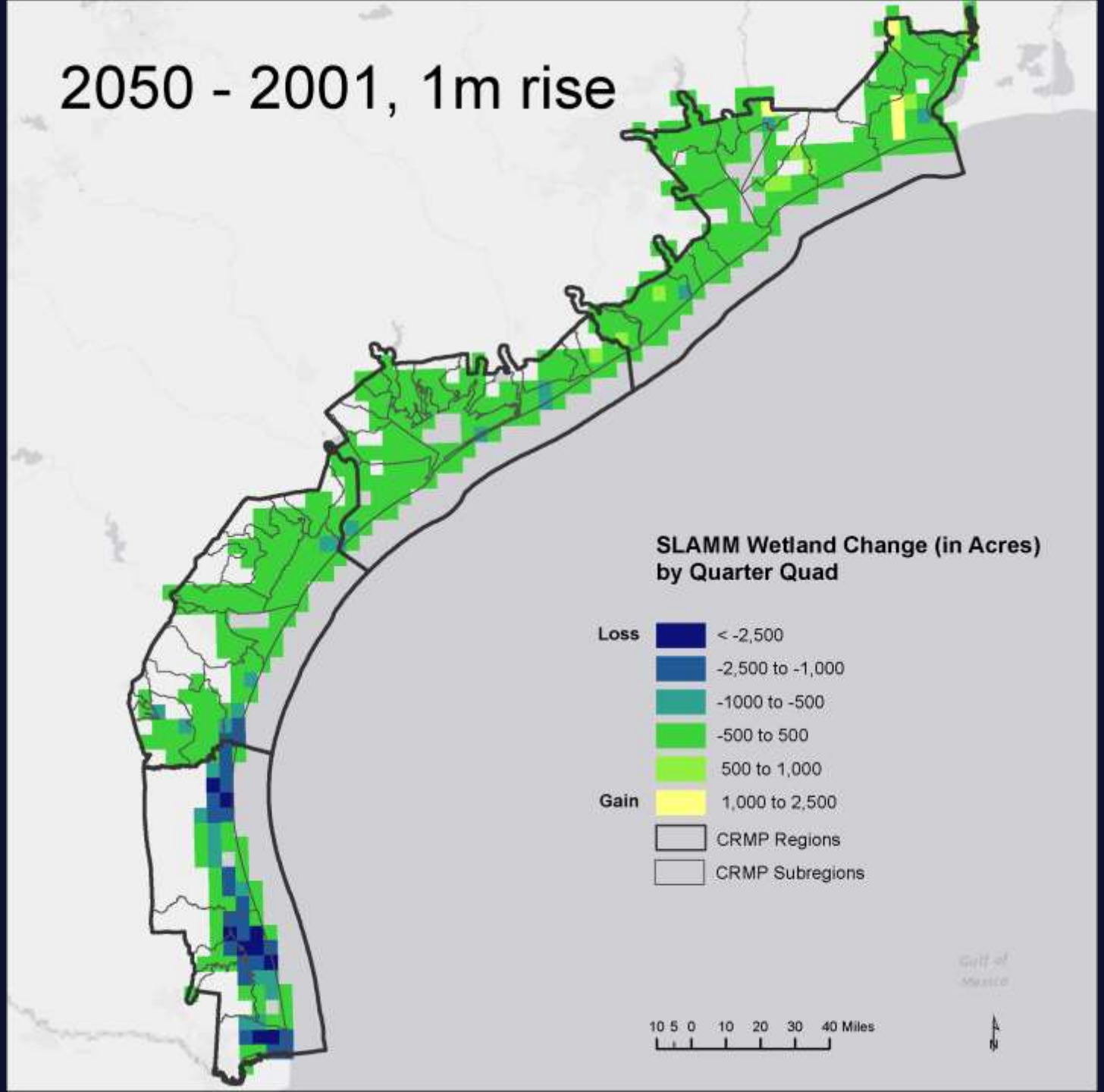
1.1km

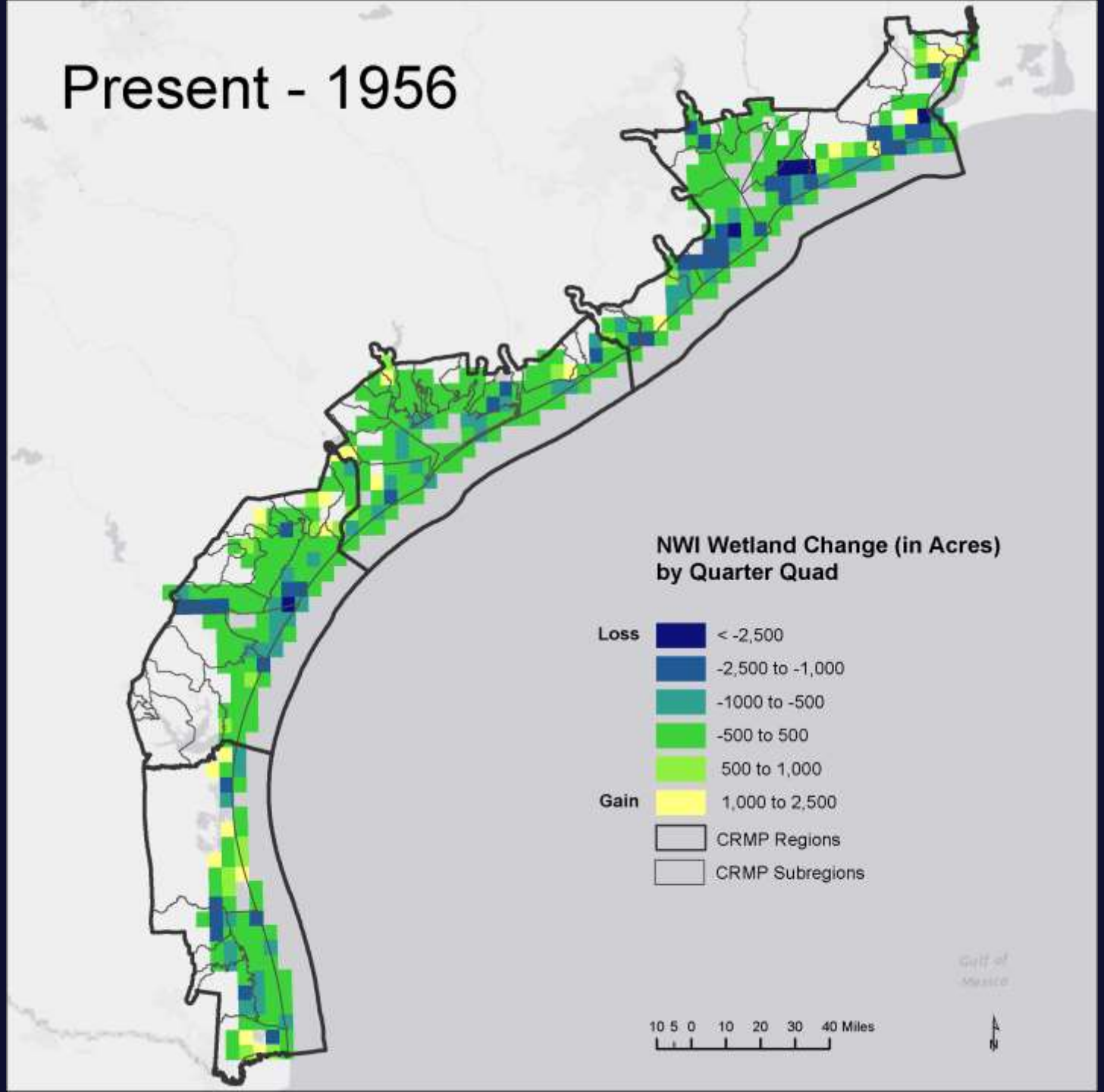
AVHRR

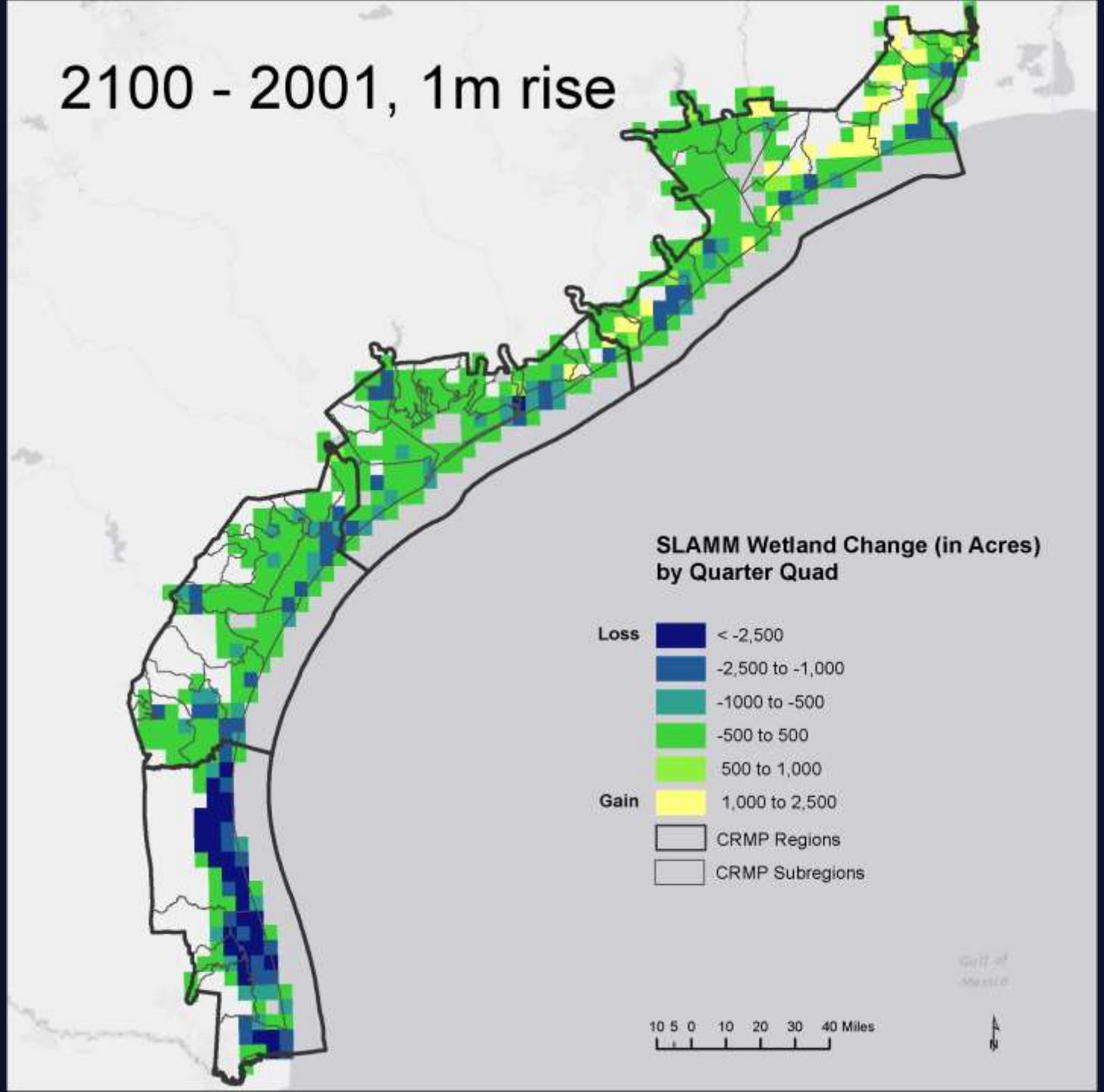
*Simulated

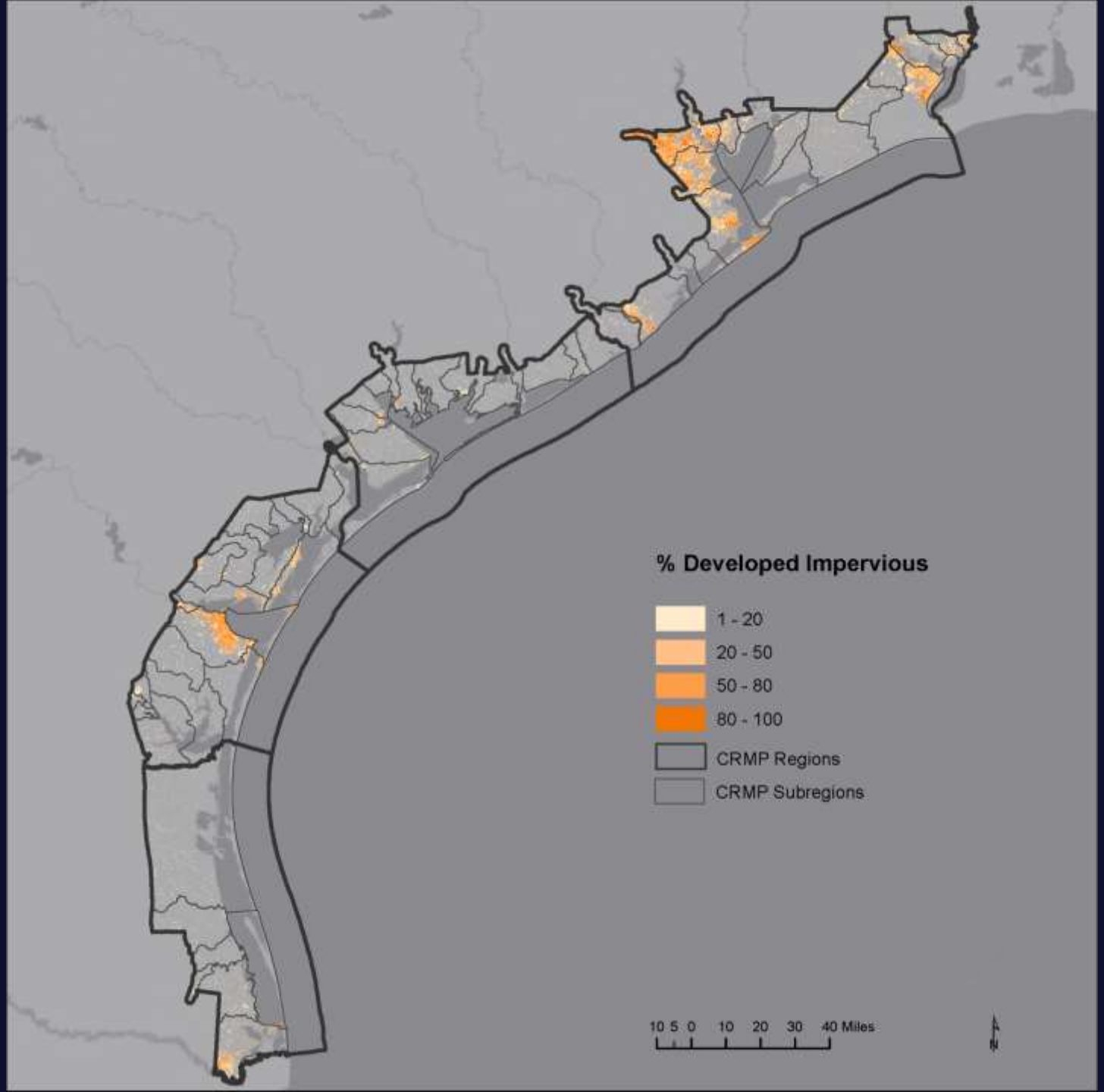
Slide courtesy of Amy Nuenschwander, Univ of Texas, Center for Space Research


Spatial and Temporal Resolution for Selected Applications
Temporal Resolution (Years)
100
10
1
0.1
0.01
0.001
0.0001
Geology
Topography
Forestry
Land-use
Land-cover
Utility, Transportation Infrastructure
Precision Agriculture
Crop Type, Yield
Climate
Emergency Response
Weather Prediction
Increasing Spatial and Temporal Resolution
1 satellite: 16 day revisit
2 satellites: 8 day revisit
3 satellites: 4 day revisit
GOES
Aerial Photography
DigitalGlobe
IKONOS/ImageSat
SPOT
IKONOS/DG/OV-3
IRS 1C
SPOT
Thematic Mapper
ASTER
Landsat MSS
ASTER
MODIS
AVHRR
GOES
0.1 m
1 m
10 m
100 m
1 km
10 km
100 km
Nominal Spatial Resolution


2050 - 2001, 1m rise
SLAMM Wetland Change (in Acres)
by Quarter Quad
Loss
< -2,500
-2,500 to -1,000
-1000 to -500
-500 to 500
500 to 1,000
Gain
1,000 to 2,500
CRMP Regions
CRMP Subregions
10 5 0 10 20 30 40 Miles
N


Present - 1956
NWI Wetland Change (in Acres)
by Quarter Quad
Loss
< -2,500
-2,500 to -1,000
-1000 to -500
-500 to 500
500 to 1,000
Gain
1,000 to 2,500
CRMP Regions
CRMP Subregions
10 5 0 10 20 30 40 Miles
N


2100 - 2001, 1m rise
SLAMM Wetland Change (in Acres)
by Quarter Quad
Loss
< -2,500
-2,500 to -1,000
-1000 to -500
-500 to 500
500 to 1,000
Gain
1,000 to 2,500
CRMP Regions
CRMP Subregions
10 5 0 10 20 30 40 Miles
N


% Developed Impervious
1 - 20
20 - 50
50 - 80
80 - 100
CRMP Regions
CRMP Subregions
10 5 0 10 20 30 40 Miles
N

NOAA's Coastal Change Analysis Program (C-CAP) 1985 to 2010 Regional Land Cover Change Data - Coastal United States (NODC Accession 0121254)
Metadata Updated: February 2, 2017

The NOAA Coastal Change Analysis Program (C-CAP) produces national standardized land cover and change products for the coastal regions of the U.S. C-CAP products inventory coastal intertidal areas, wetlands, and adjacent uplands with the goal of monitoring changes in these habitats, on a one-to-five year repeat cycle. C-CAP data exists nationwide for the coastal regions of the lower 48 states for 1996, 2001, 2006, and 2010, and in selected locations for 1985 and 1992. These maps are developed utilizing Landsat Thematic Mapper imagery, and can be used to track changes in the landscape through time. This trend information gives important feedback to managers on the success or failure of management policies and programs and aid in developing a scientific understanding of the Earth system and its response to natural and human-induced changes. This understanding allows for the prediction of impacts due to these changes and the assessment of their cumulative effects, helping coastal resource managers make more informed regional decisions. NOAA C-CAP is a contributing member to the Multi-Resolution Land Characteristics consortium and C-CAP products are included as the coastal expression of land cover within the National Land Cover Database.
Purpose: C-CAP is dedicated to the development, distribution, and application of land cover and change data for the coastal regions of the U.S. This effort is being conducted in close coordination with state coastal management agencies, the interagency Multi-Resolution Land Characteristics (MRLC) consortium, and the National Land Cover Database (NLCD).

Ensuring a data and information legacy that promotes continual scientific discovery and public awareness of the Gulf of Mexico.

GRIIDC Repository Serves Data Life Cycle

Plan → Track → Document → Archive → Disseminate

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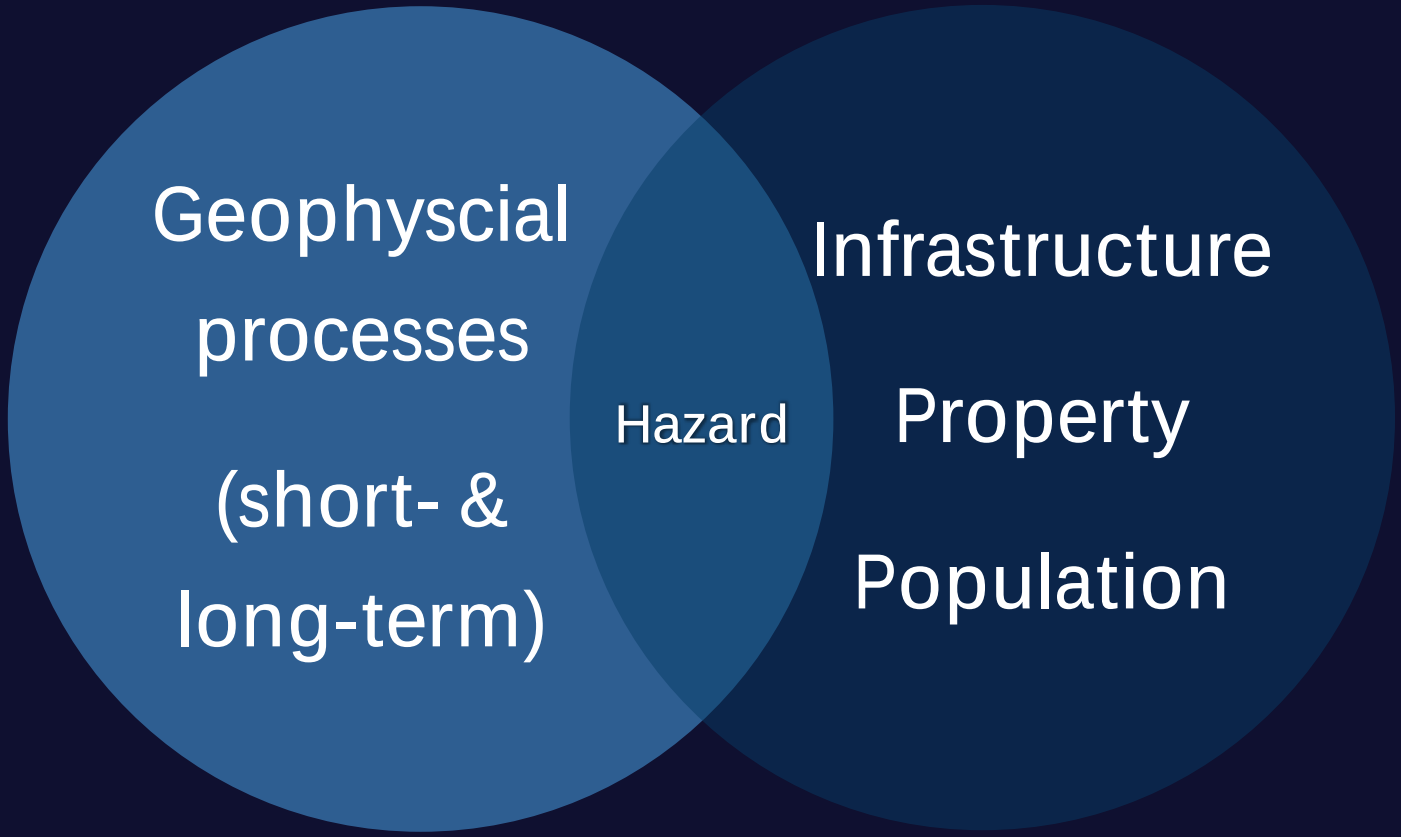

Geophyscial processes
(short- & long-term)
Hazard
Infrastructure
Property
Population

Texas Coast

Shoreline Length:

Gulf = 600 km

Bays = 9,400 km

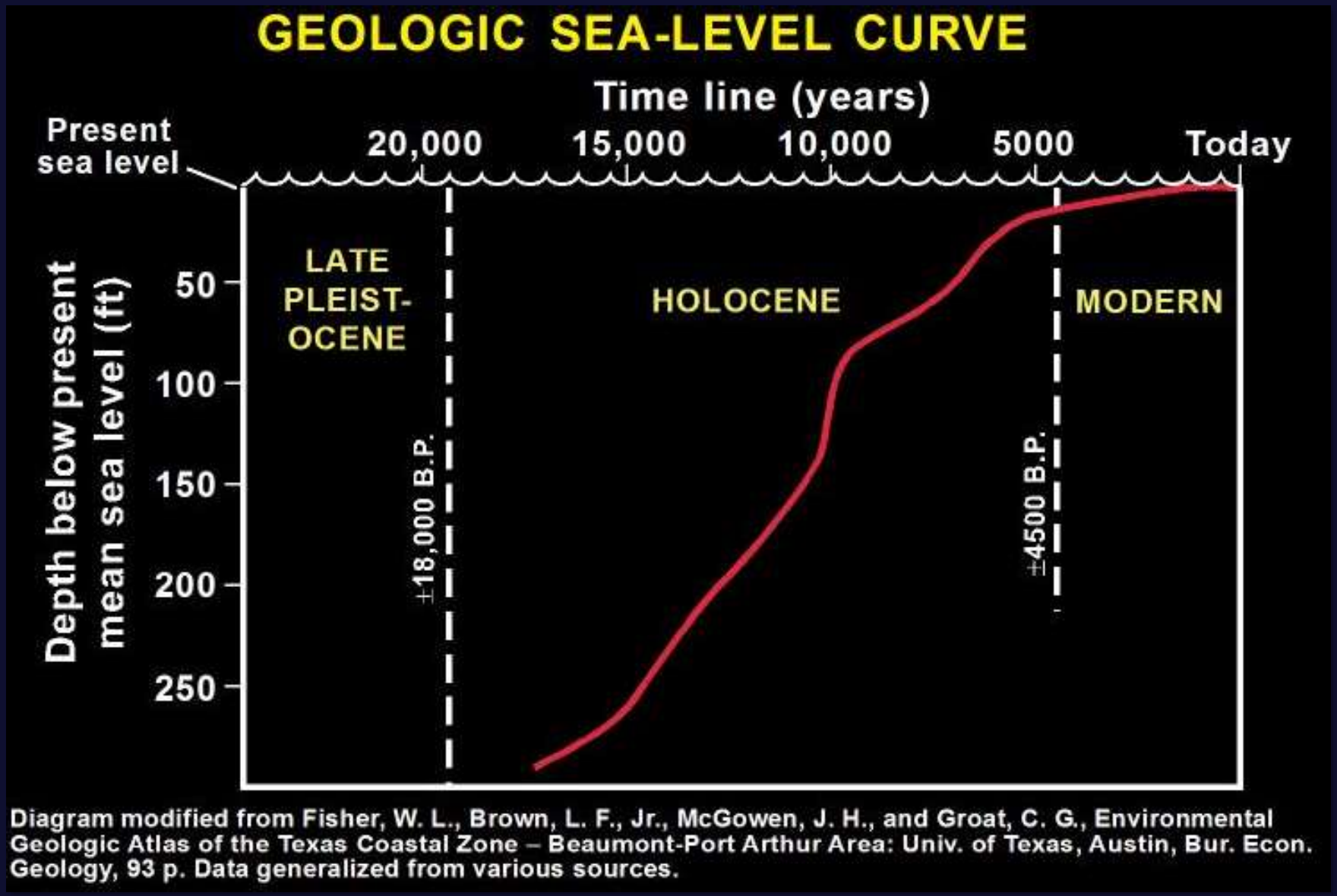
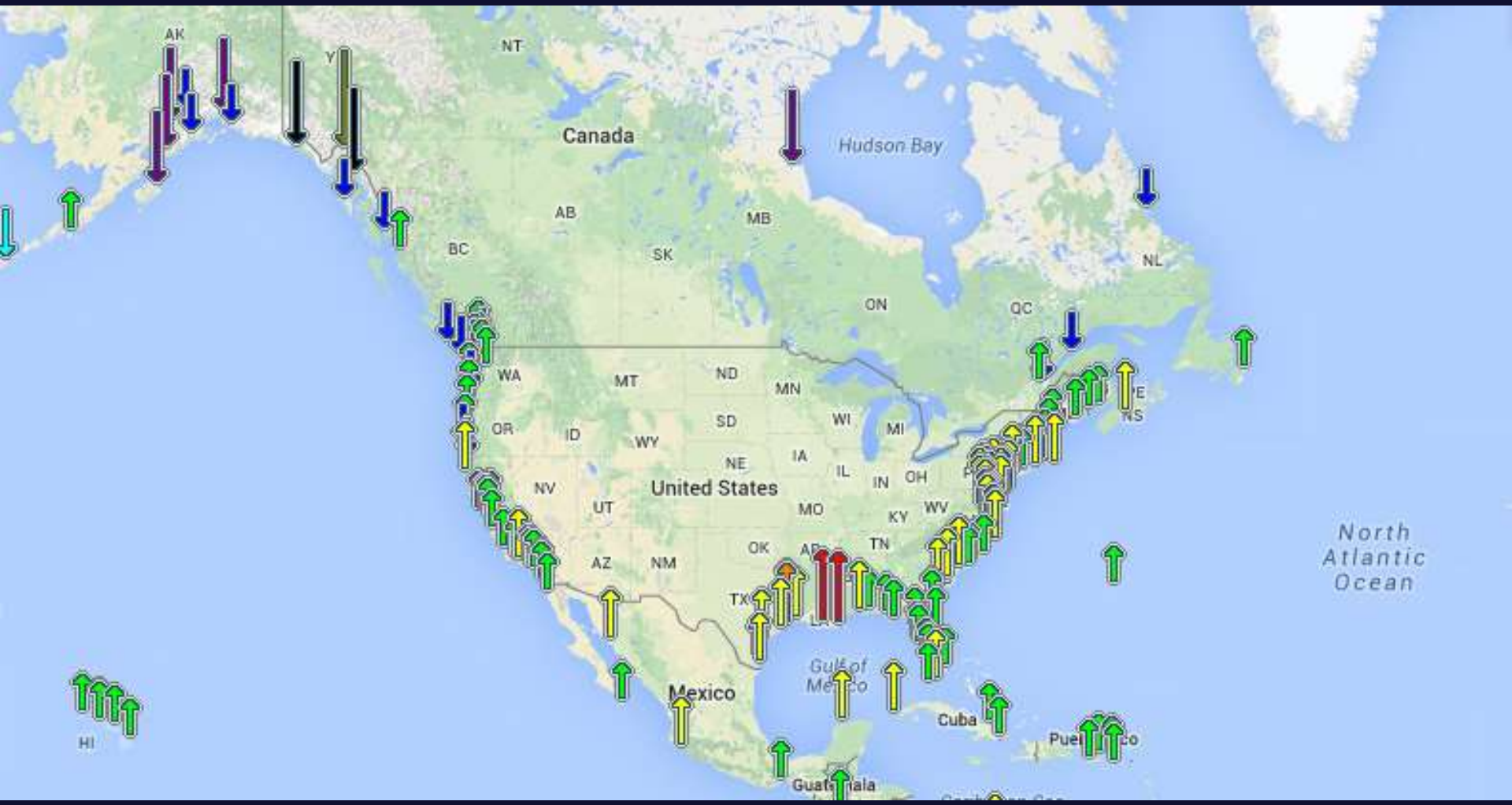


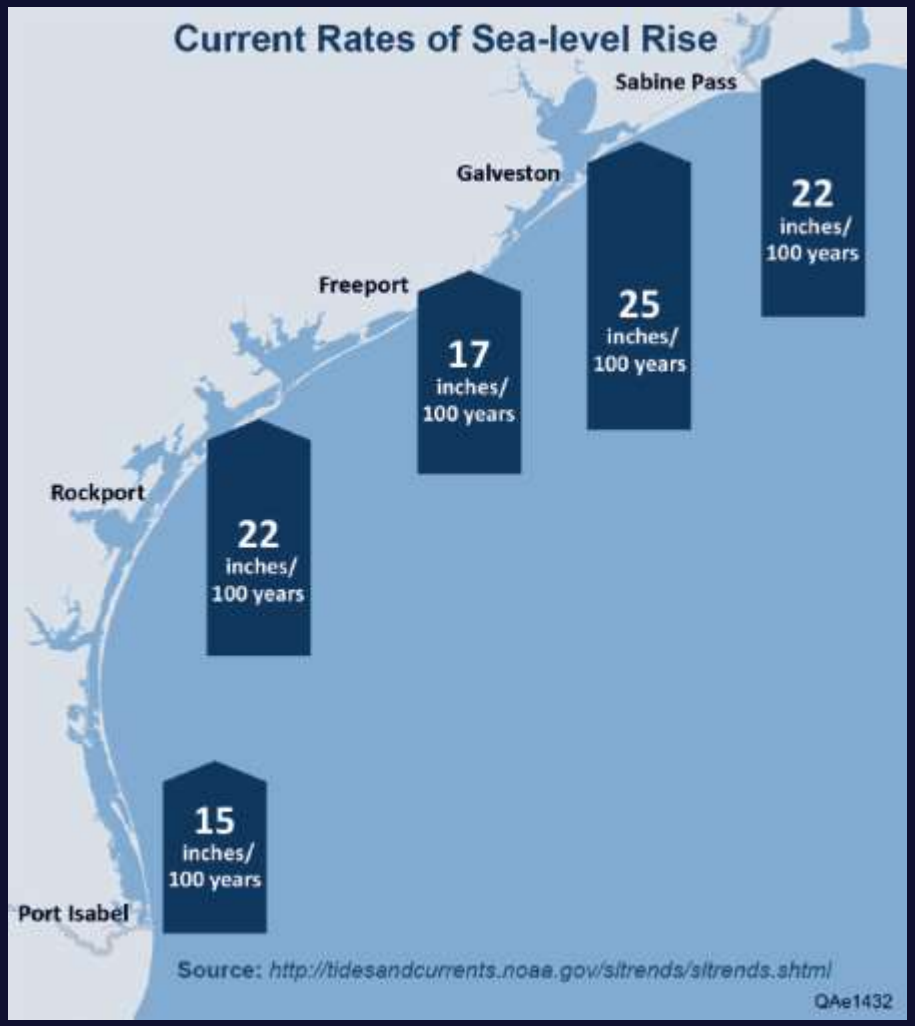
Diagram modified from Fisher, W. L., Brown, L. F., Jr., McGowen, J. H., and Groat, C. G., Environmental Geologic Atlas of the Texas Coastal Zone – Beaumont-Port Arthur Area: Univ. of Texas, Austin, Bur. Econ. Geology, 93 p. Data generalized from various sources.

Relative sea-level rise trends from tide gauges



(NOAA, 2014)

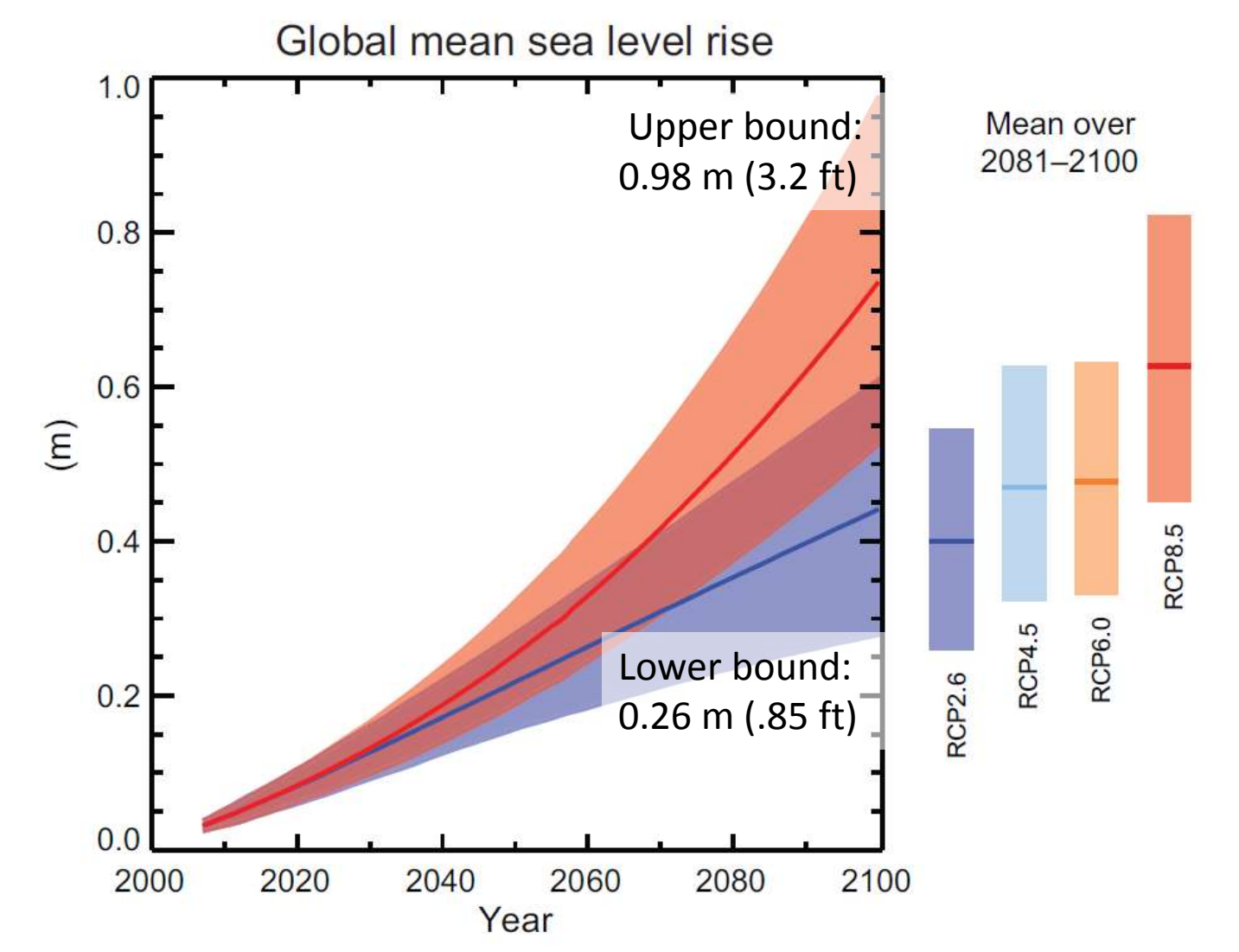
Actual sea-level rise along the Texas coast during last 50 to 100 years



~1 – 2 ft
per 100 years

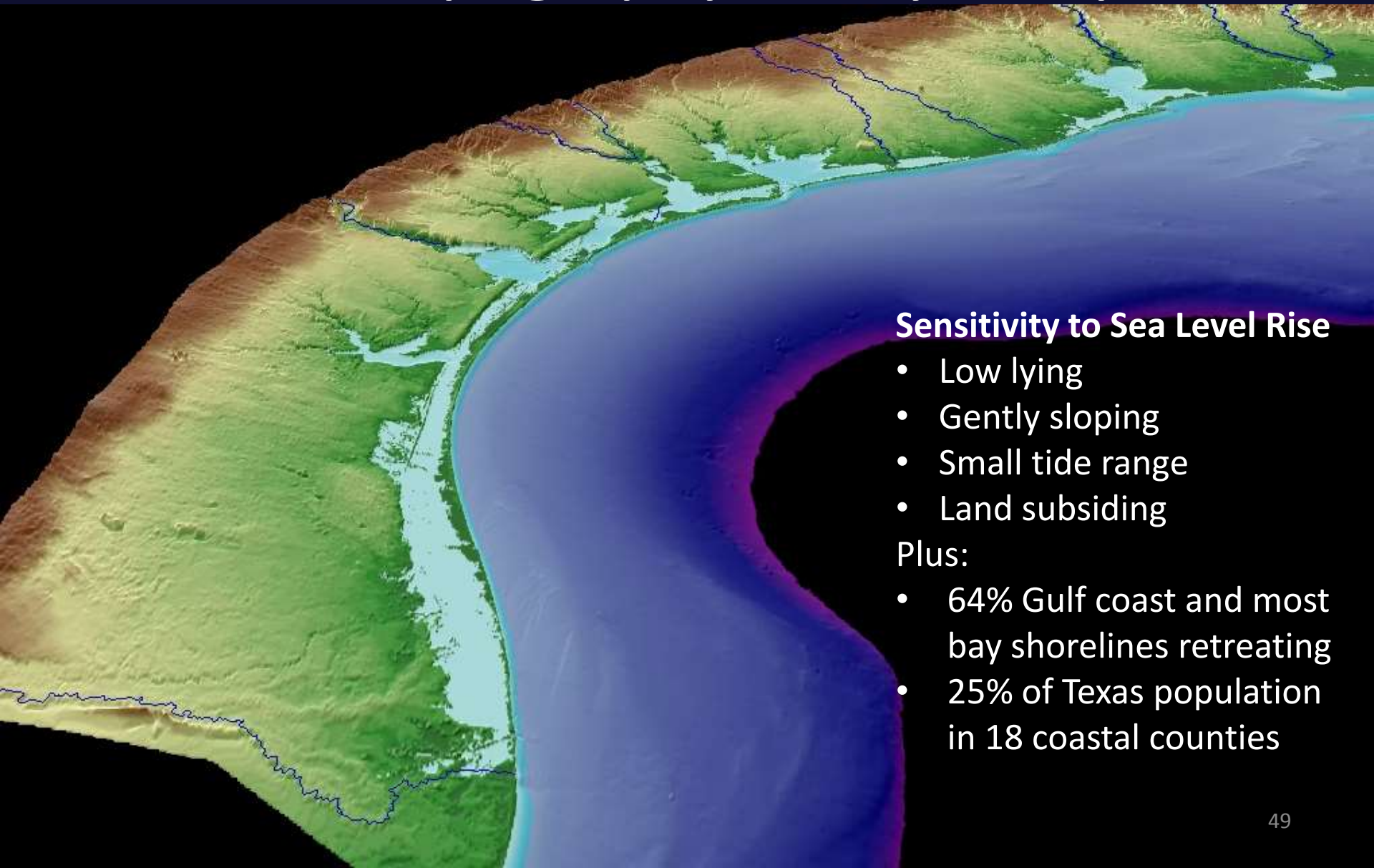
(BEG & Energy Institute, 2013)

Projections of global mean sea-level rise



(IPCC 5th Assessment Report, 2013)

Texas Coastal Plain Topography/Bathymetry



Sensitivity to Sea Level Rise

- Low lying
- Gently sloping
- Small tide range
- Land subsiding

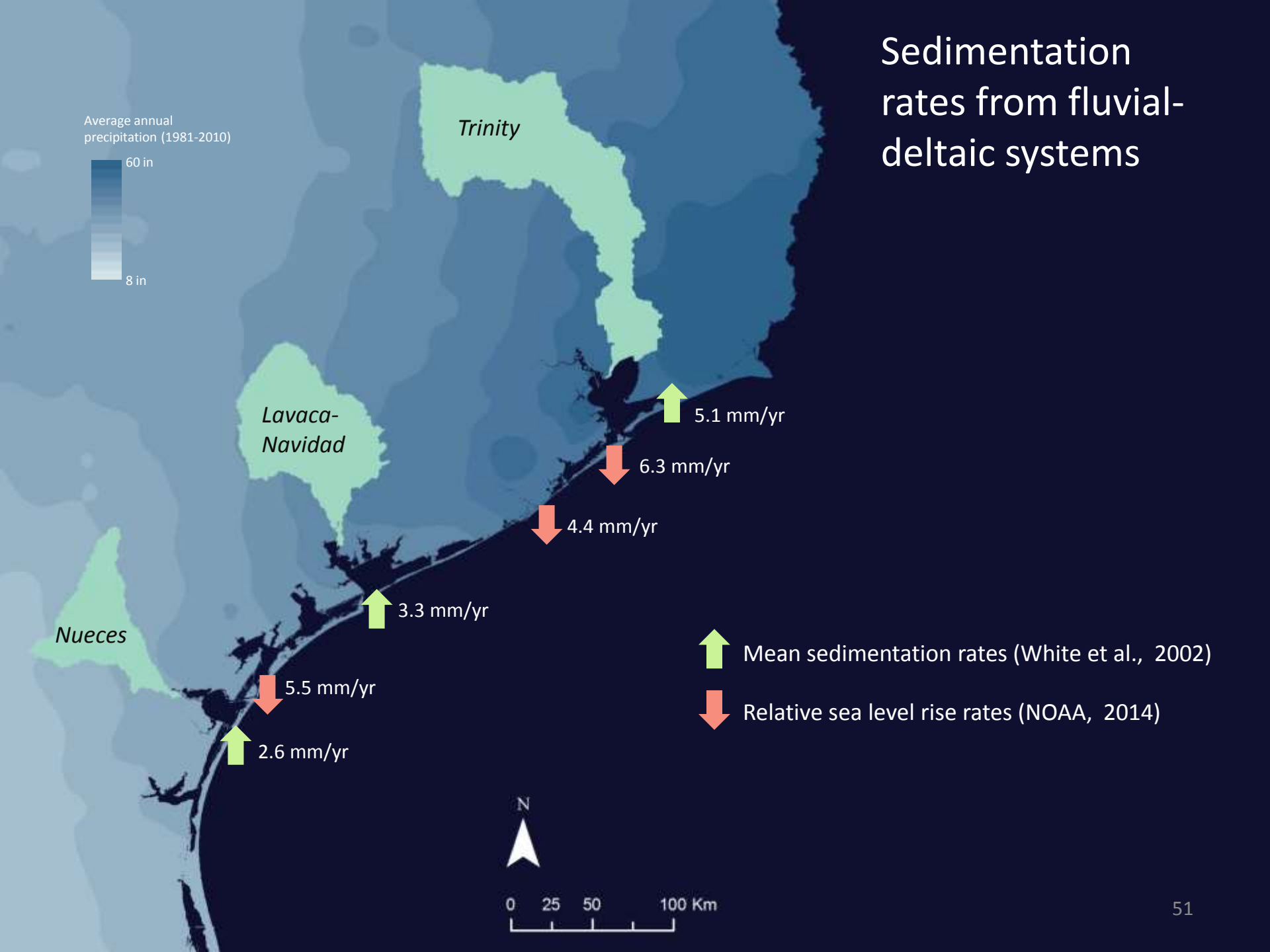
Plus:

- 64% Gulf coast and most bay shorelines retreating
- 25% of Texas population in 18 coastal counties

Protective barrier islands have and will change because of sea level rise

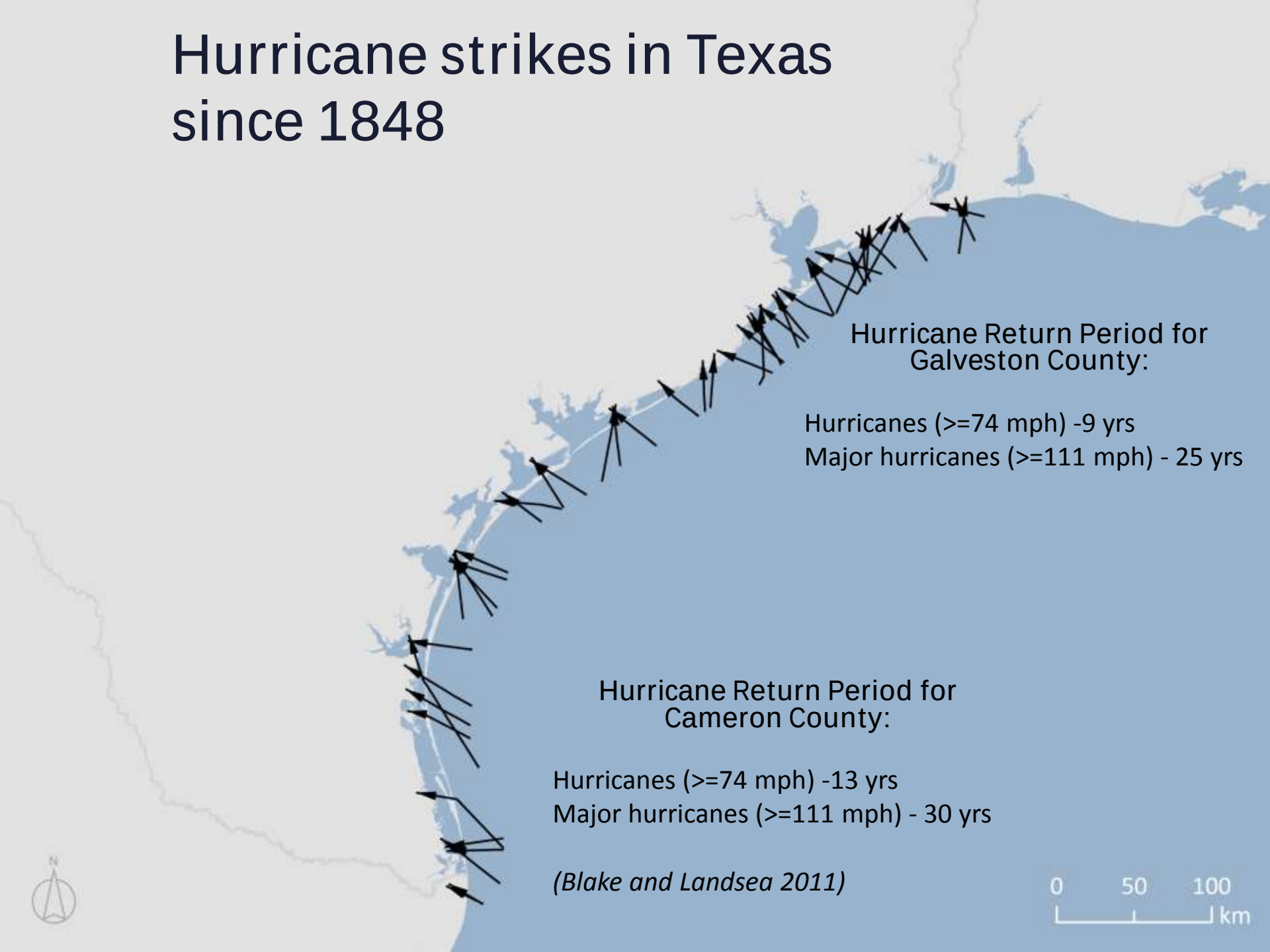
Mustang Island will tend to become more like Matagorda Peninsula

Sedimentation rates from fluvial-deltaic systems

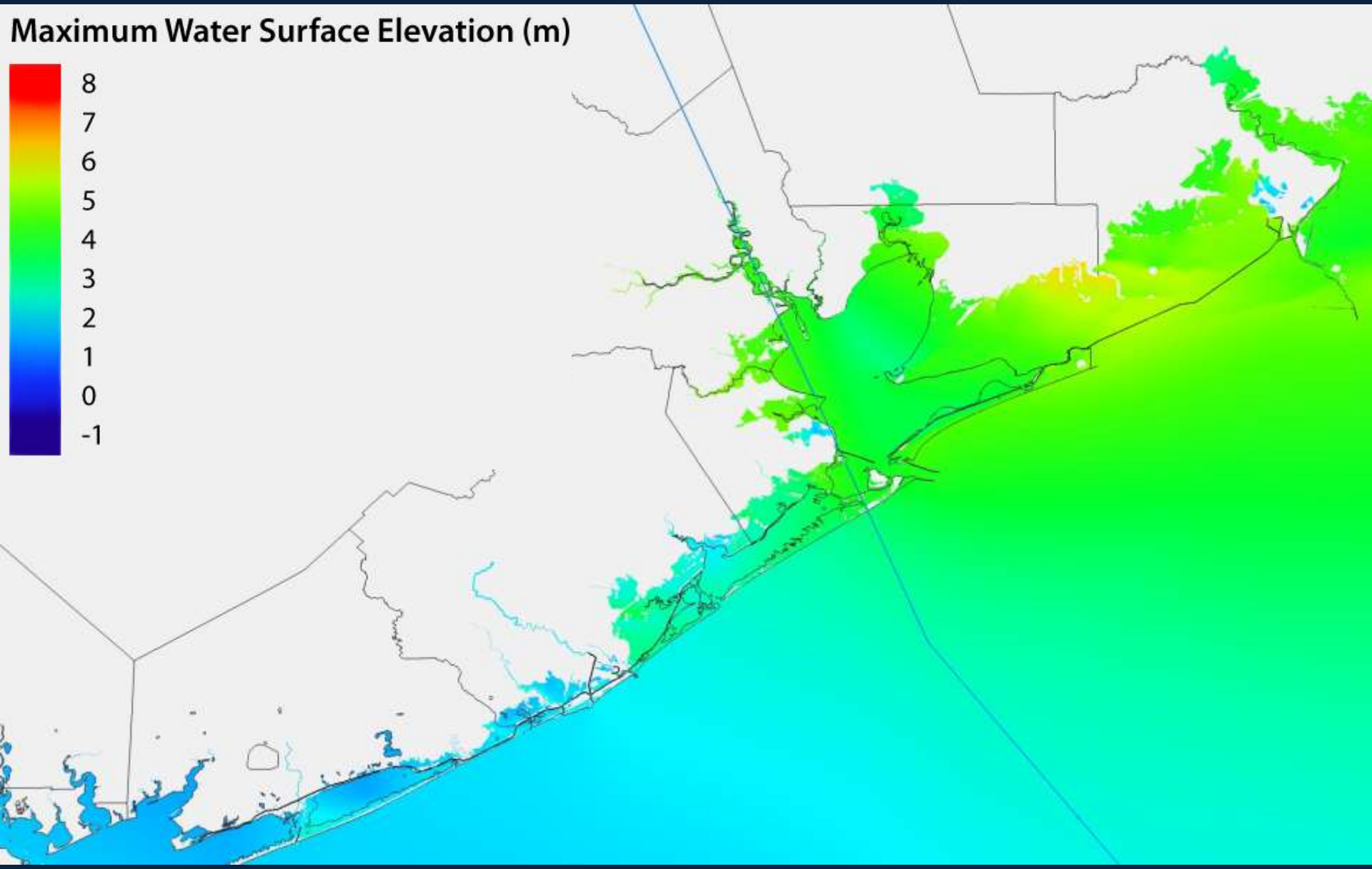


Nueces River Delta

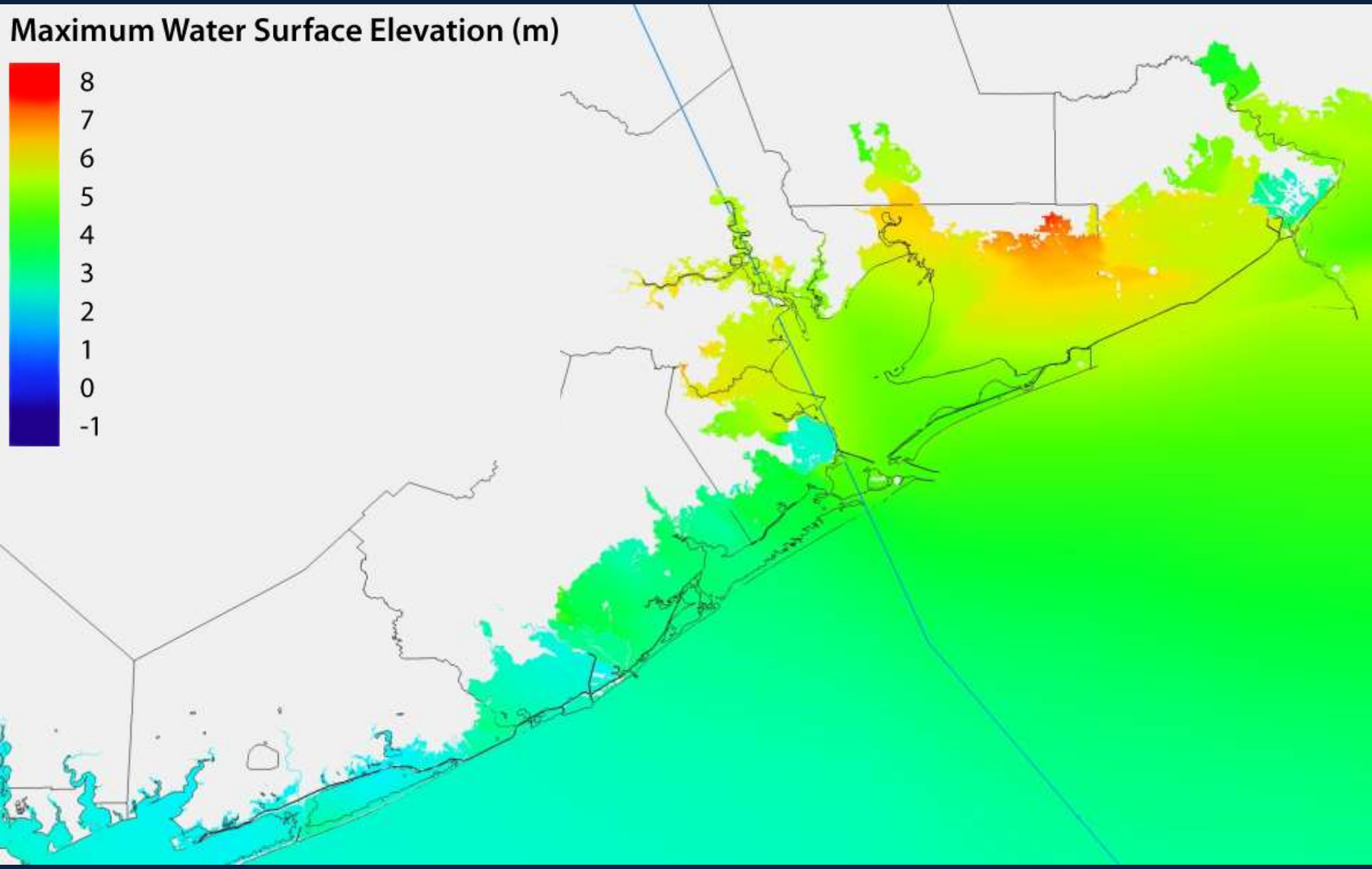
Hurricane strikes in Texas since 1848



Maximum Storm-Surge Elevation during Hurricane Ike 2008



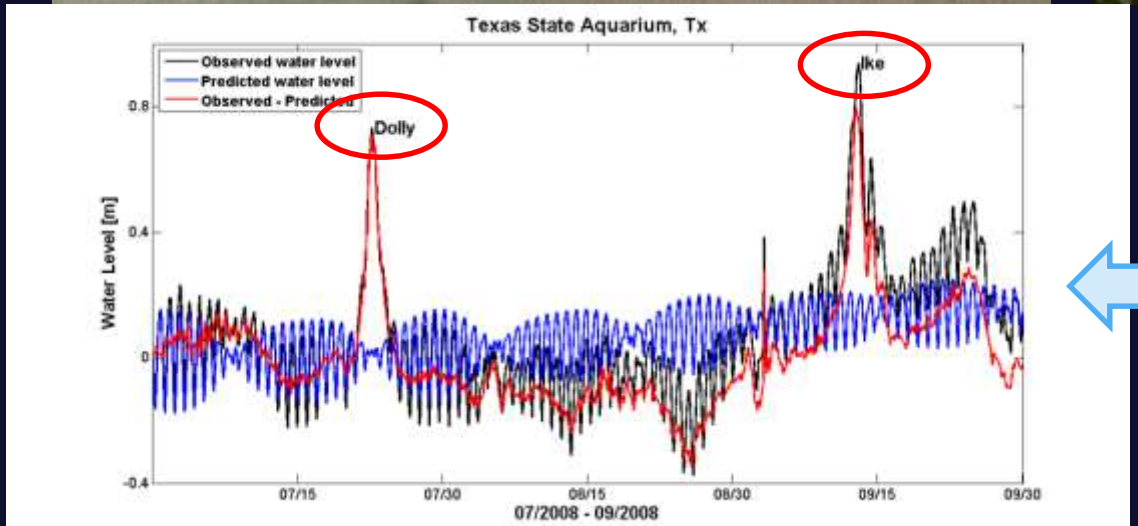
Maximum Storm-Surge Elevation during Hurricane Ike
2100



TEXAS A&M UNIVERSITY CORPUS CHRISTI | CONRAD BLUCHER INSTITUTE FOR SURVEYING AND SCIENCE

Nuisance Flooding: Changes in Inundation Frequency

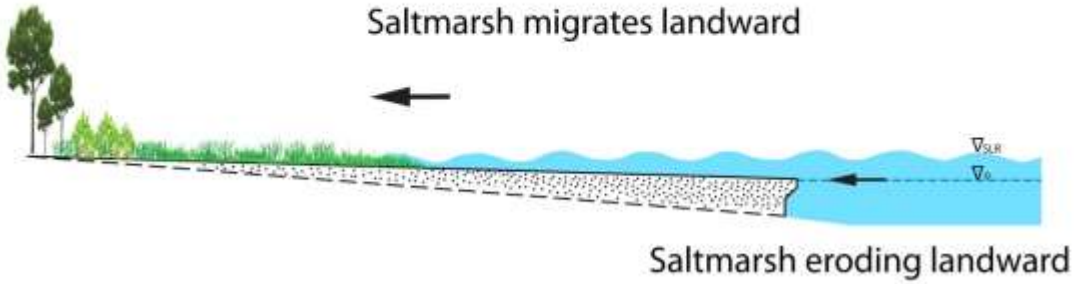
As the century progresses coastal communities will have to deal with increasingly frequent small to medium inundations resulting in growing insurance claims.



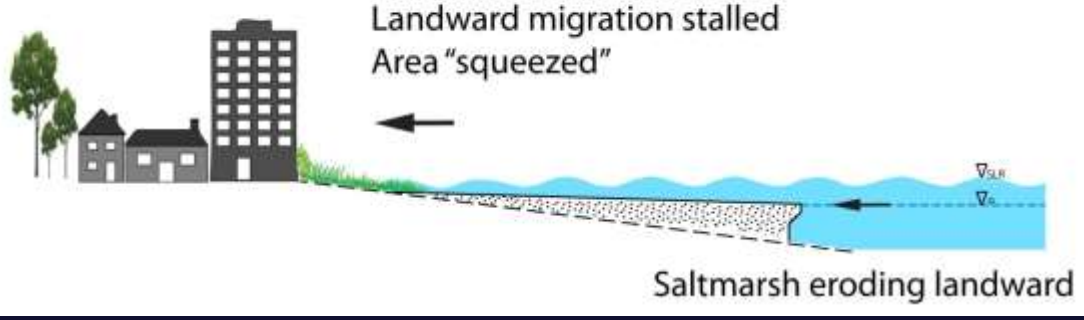
Corpus Christi
North Beach
2 inundations in 2008

Tissot & Reisinger, 2016 GCAGS

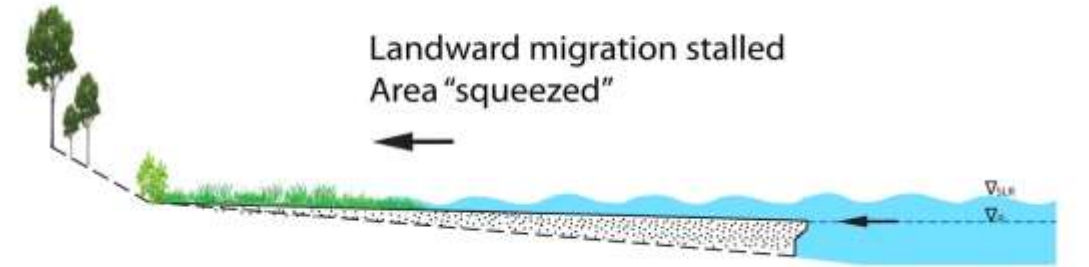
a.) Natural saltmarsh migration



b.) Coastal squeeze due to development

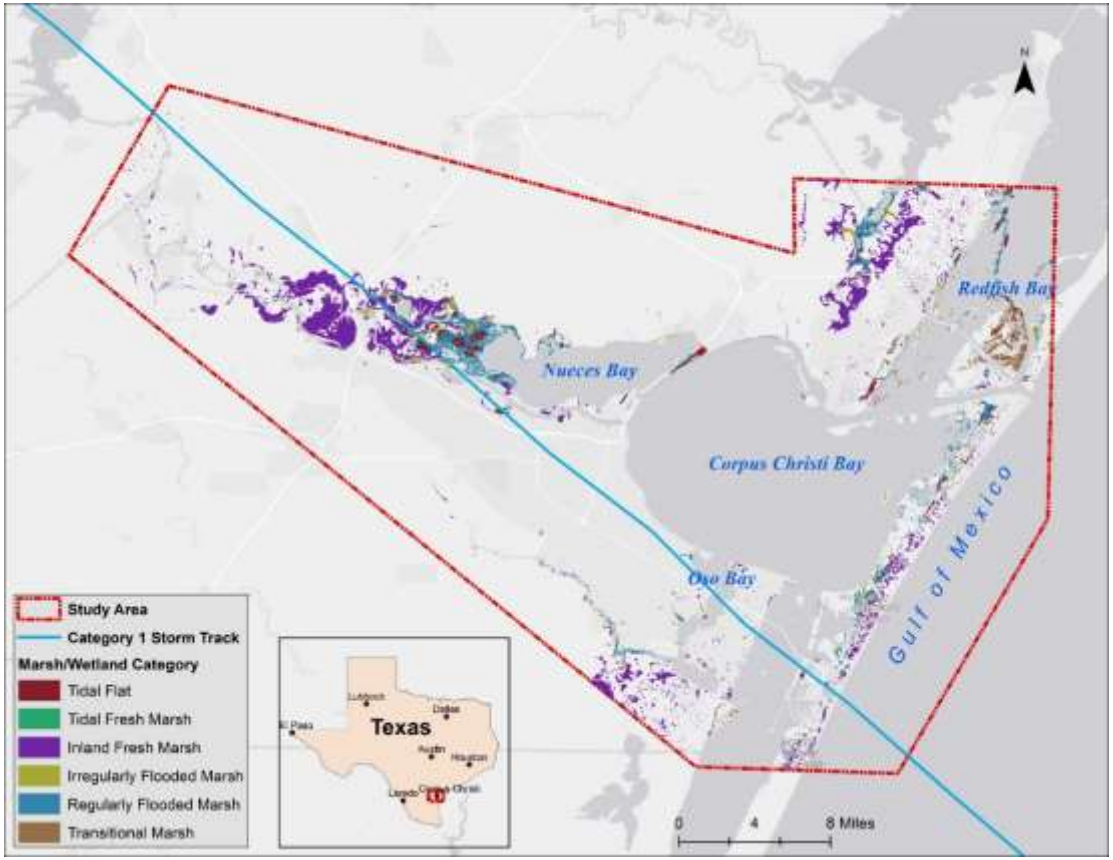


c.) Coastal squeeze due to naturally rising land



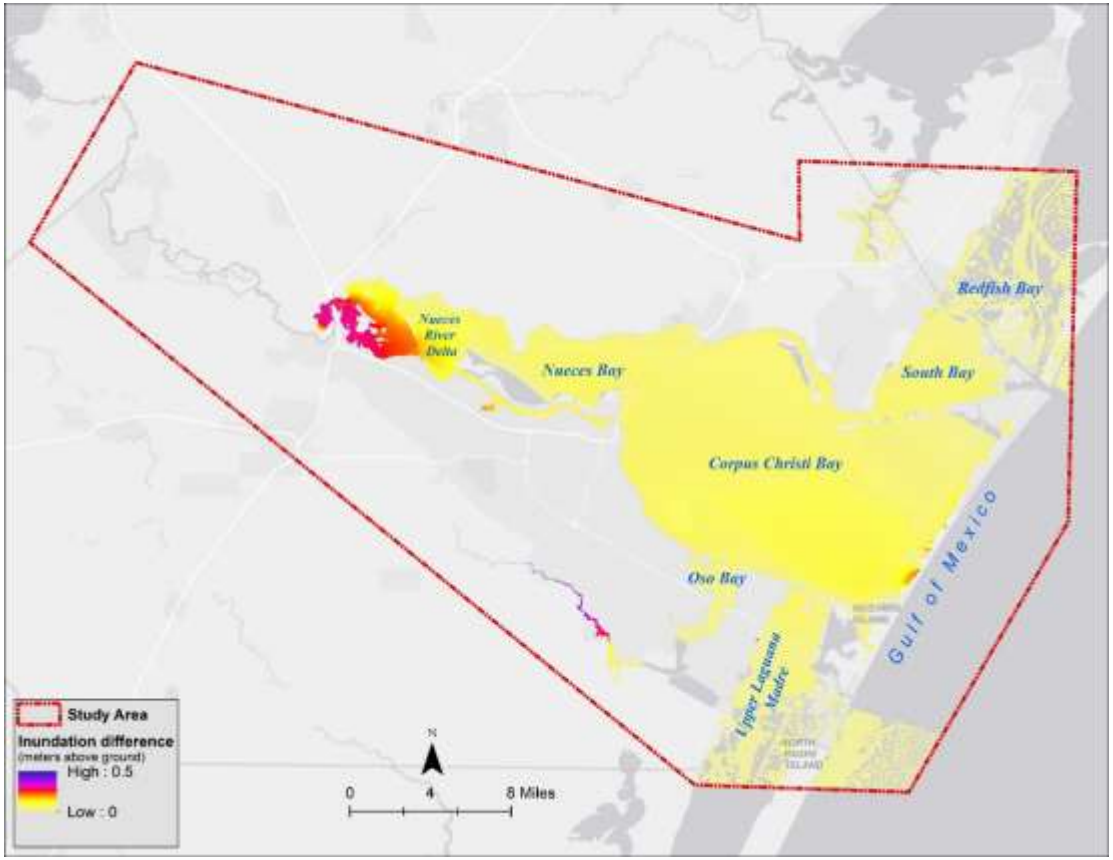
(Based on Brinson et al., 1995)

Wetlands in the Corpus Christi Area



Wetland Categories	Area (hectares)
Tidal Flat	1,264
Tidal Fresh Marsh	3
Inland Fresh Marsh	8,648
Irregularly Flooded Marsh	1,245
Regularly Flooded Marsh	3,390
Transitional Marsh	670
Total Area	**15,220**

Difference in Surge with and without Marshes

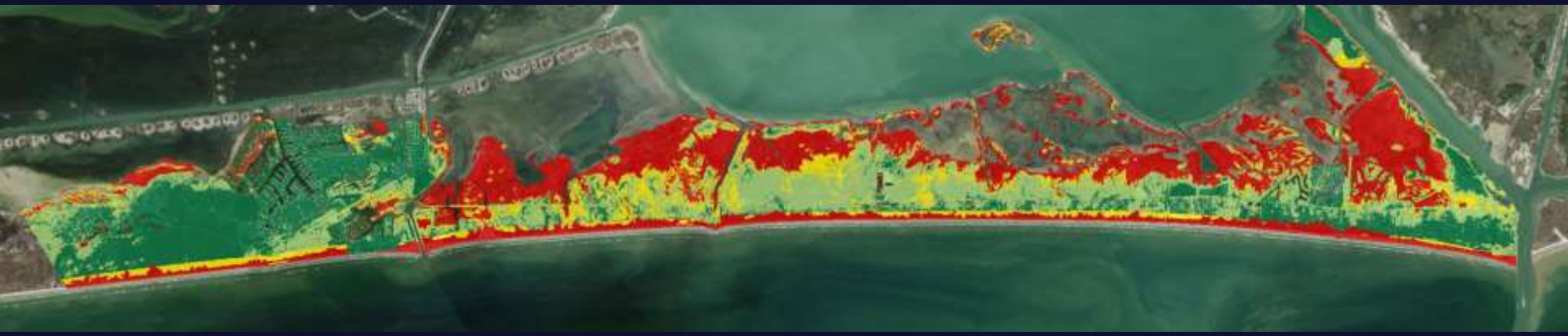


Key Findings:
Additional 385 hectare of land is inundated with the loss of marshes in the area.
Largest difference in inundation levels are observed in the Nueces River floodplain, upstream of Oso Creek, and regions adjacent to the barrier island.

Socio-economic Loss Analysis

Key Findings: (This analysis considers both Nueces and San Patricio County in 2010 US $ value and Census data.)
The loss of marshes in the region resulted in total $95 million direct economic losses for buildings, $55.7 million depreciated direct economic losses for buildings, $22 million economic losses for vehicles, and $637,750 economic losses for utilities.
The loss of marshes in the region resulted in 67 buildings to be damaged.
The loss of marshes in the region resulted in total of 101 displaced household, 303 displaced people, and 299 people needing short-term shelter.
The storm surge protection value provided by the marshes in the region is $6,244 per hectare of marsh, considering only the direct economic losses for buildings.

Geohazards Map
Mustang and North Padre Islands



- Imminent Geohazard Potential
  Today's critical environments: wetlands, beaches, and dunes
- High Geohazard Potential
  Future critical environments: Areas expected to become critical environments in 60 years' time (2062)
- Moderate Geohazard Potential
  Low upland areas not expected to become critical environments but are inundated by low-intensity storms
- Low Geohazard Potential
  Island core upland: Centrally located upland areas generally more than 5 feet above sea level

Summary

Sea level rise has and will continue to drive major changes in coastal Texas during the next decades.

We need space and sediment to ensure survival of low-lying and intertidal environments.

We need these environments for the ecosystem services they provide us.