

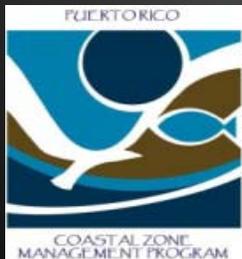
Department of Natural and Environmental Resources



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Impactos del Cambio Climático en Zonas Costero-Marinas de Puerto Rico



5 de agosto 2011
Sheraton Old San Juan



Presentation Outline

1. Climate Change 101
2. History of Climate Change Efforts in Puerto Rico
3. The Puerto Rico Coastal Adaptation Project
4. Preliminary Findings
 1. Underlying Vulnerabilities
 2. Precipitation
 3. Temperature
 4. Sea Level Rise
5. Challenges for the Coasts
6. Options for Coastal Management

Climate Change 101

- These slides were deleted due to copyright. If you would like to schedule a climate change 101 presentation please contact Kasey Jacobs at kaseyrjacobs@gmail.com or visit www.theclimateproject.org to request a presentation from one of the eight Puerto Rico presenters.

ESTUDIO SOBRE LA PERCEPCIÓN PÚBLICA DE LOS
**CAMBIOS CLIMÁTICOS Y
LOS RIESGOS NATURALES**
SEGMENTO OESTE DE PUERTO RICO

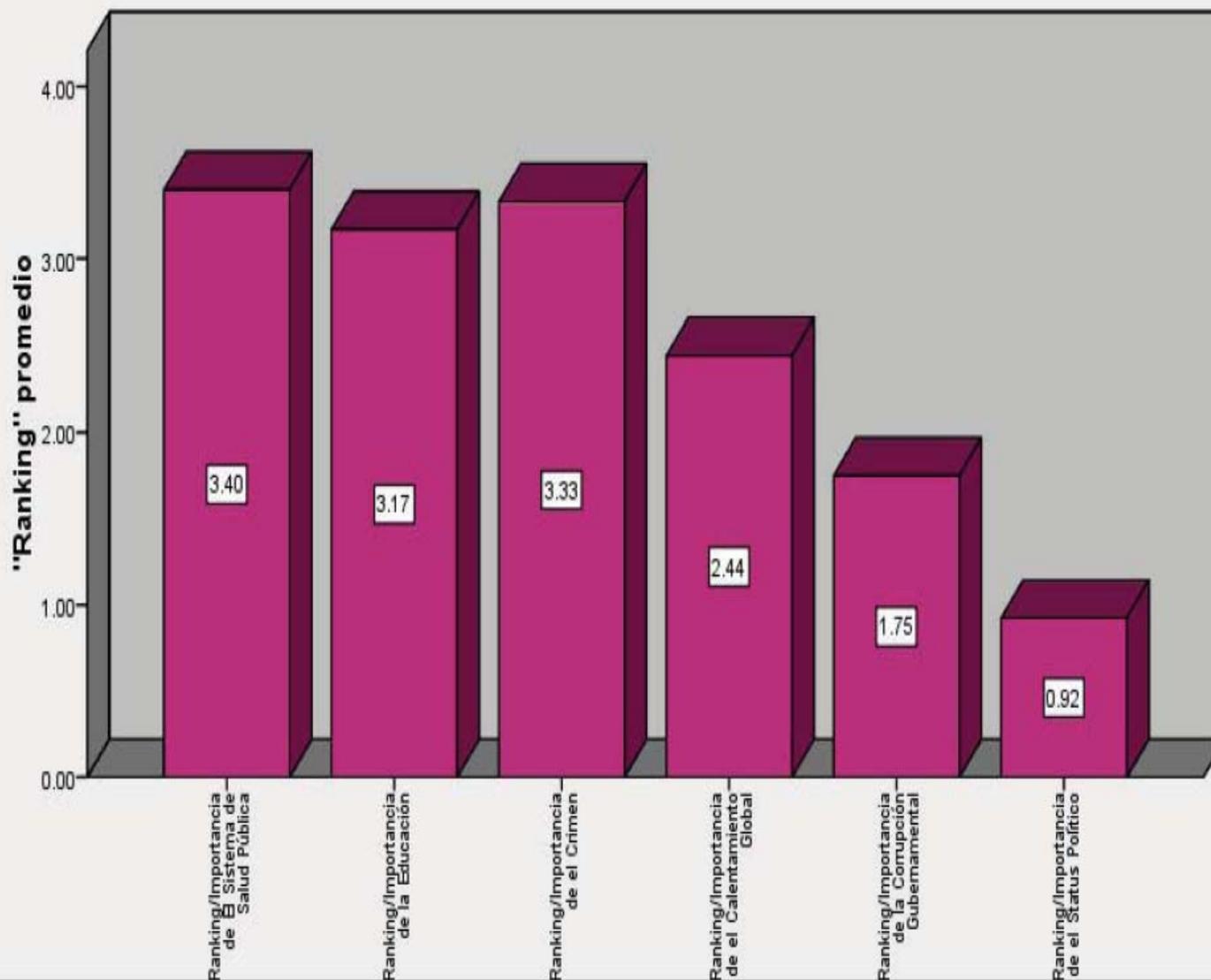


Sea Grant
Puerto Rico



SEPTIEMBRE 2009

Importancia relativa ("ranking") asignada a 6 temas de interés público



n=600 Escala de 0-5. A mayor puntuación, mayor importancia.

CLIMATE CHANGE EFFORTS IN PUERTO RICO

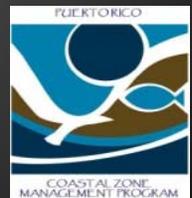
- Citizens of the Karst – 2007 Climate Change Declaration to Government and Citizens of Puerto Rico
- 2007 and 2009 Roundtables on Climate Change (Dr. Rafael Mendez Tejeda, UPRM and Dr. Ruperto Chaparro, Sea Grant)
- 2008 Puerto Rico Global Warming Commission (Executive Order)
- U.S. Global Change Program's "Global Climate Change Impacts in the United States" (USGCRP, 2009)
- White House Task Force on Climate Change and the National Climate Assessment – U.S. Caribbean included for 2013!!

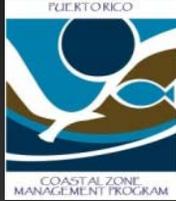


Puerto Rico Coastal Adaptation Project:

Primary outputs will be:

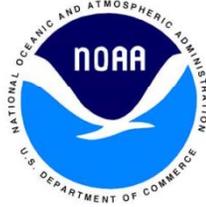
- 1. Vulnerability Assessment for multiple sectors**
- 2. Recommended Adaptation Strategies and Policies**





Puerto Rico Coastal Adaptation Project

- Utilizar la mejor información científica disponible para identificar las comunidades y ecosistemas más amenazados por riesgos costeros y cambio climático.
- Identificar, evaluar, priorizar, y desarrollar estrategias de adaptación y políticas públicas eficaces que puedan aplicarse en Puerto Rico.
- Comunicar los resultados, consensos y recomendaciones al gobierno, la sociedad civil, los medios de comunicación, y el sector privado.
- Lograr una sociedad puertorriqueña bien informada acerca de los peligros costeros, la adaptación y la mitigación al cambio climáticos.



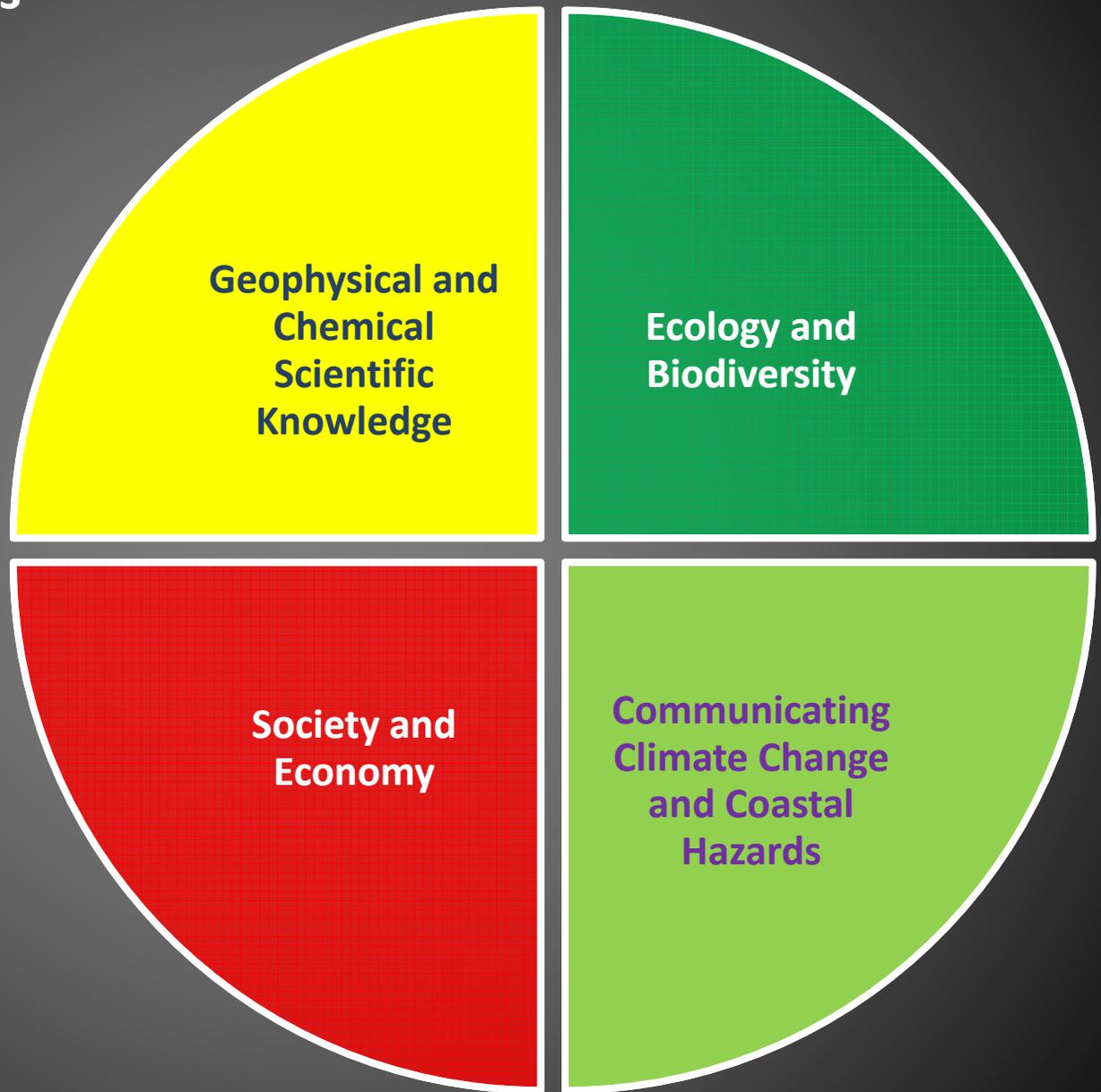
Bahía de Jobos

Un estuario diferente...



CCRI

**Four Working Groups
for the Puerto Rico
Climate Change
Community (PRCCC)**



Reporting on Historic Trends and Possible Future
Climate Conditions for the following parameters:

Air temperatures

Precipitation

Extreme Precipitation

Sea Level Rise

Winter Swells/Nor'easters

Sea Surface Temperatures

Tropical Storms and Hurricanes

Ocean Acidification

**Geophysical and Chemical Scientific
Knowledge: Scenario Building**

Ecology and Biodiversity

Beach Ecosystems

Emergent Wetlands

Coral Reefs

Submerged Aquatic

Vegetation

Lagoons/Biobays

Cays and Islets

Amphibians (e.g., Coquis)

Sea Turtles

Marine Mammals

Puerto Rican Parrot

Sea birds and coastal

Waterfowl

Coastal and pelagic fish
species

Contaminants and Wildlife

Forests (coastal forests,

Caribbean National forest, dry
forests, etc)



Society and Economy

Economic Development

Livelihoods

*Mining of mineral
resources*

Tourism and Recreation

Industry

Fisheries

Energy

Critical Infrastructure

Coastal Communities

Water resources

**Historical and Cultural
Preservation**

Disaster Management

**Population Growth and
Development Trends**

Social Vulnerability

Health



Communicating Climate Change and Coastal Hazards





Seguro



Saludable



Sostenible



Productivo



Resiliente

Vision for Puerto Rico



Safe



Healthy



Sustainable



Productive



Resilient

Recruit critical partners and develop the collaboration process

- Launched PRCCC and created four working groups
- Agreed on the process and a vision for Puerto Rico
- Agreed on the sectors to be assessed. Examples: ecosystems (wetlands, forests, coral reefs), species (coqui, PR parrot), critical infrastructure, economic development, coastal communities, health, etc.
- Created the PR-CC-L



Systematically collect data and knowledge

- Develop climate scenarios for the future based on historic trends and already published climate projections for Caribbean basin (WG1)
- Create PR Climate Change Research Library
- Preliminary/Qualitative Assessment with expert input
- Risk Assessment Workshops: (1) Natural Resources and (2) Societal Infrastructure to quantify risk levels and time

July
2011

Spatial Analyses and Mapping of Vulnerabilities

- Identify socio-economic and ecological indicators of vulnerability and resilience in Puerto Rico
- Using remote sensing and GIS identify natural buffers such as dune systems, wetlands, eolianites, mangroves, cays, etc.
- Using existing Social Vulnerability Index and identified exposed/protected areas, identify at-risk communities and ecosystems

October
2011

Recommend adaptation strategies and implement outreach plan

- Complete Vulnerability Assessment Report and seek peer-review
- Identify/develop, evaluate, and prioritize adaptation strategies and policies through workshops and expert advice
- Finalize reports and create executive summaries
- Outreach and education of the key vulnerabilities and adaptation options for Puerto Rico

June
2012



Preliminary Findings of the Puerto Rico Vulnerability Assessment

- Underlying Vulnerabilities
 - Precipitation Impacts
 - Storm Surge Impacts
 - Sea Level Rise Impacts
- Possible Future Climate Conditions
 - Temperature
 - Precipitation
 - Sea Level Rise
 - Winter Swells

Underlying Vulnerabilities Existing Hazards in Puerto Rico (w/o climate change):

- Riverine and Coastal Inundation
- Landslides
- Tropical storms and Hurricanes
- Earthquakes
- Tsunamis
- Winter Swells (*“marejadas de invierno”*)
- Coastal Erosion
- Drought

Underlying Vulnerabilities Puerto Rico is at risk from:

- Continuing development in high hazard areas
- Elimination of dunes, reefs, mangroves and other naturally protective features
- Poor maintenance of existing shoreline stabilization structures
- Poor maintenance dredging of rivers, canals, and reservoirs
- Poor maintenance of stormwater systems
- Poor sediment management from the land







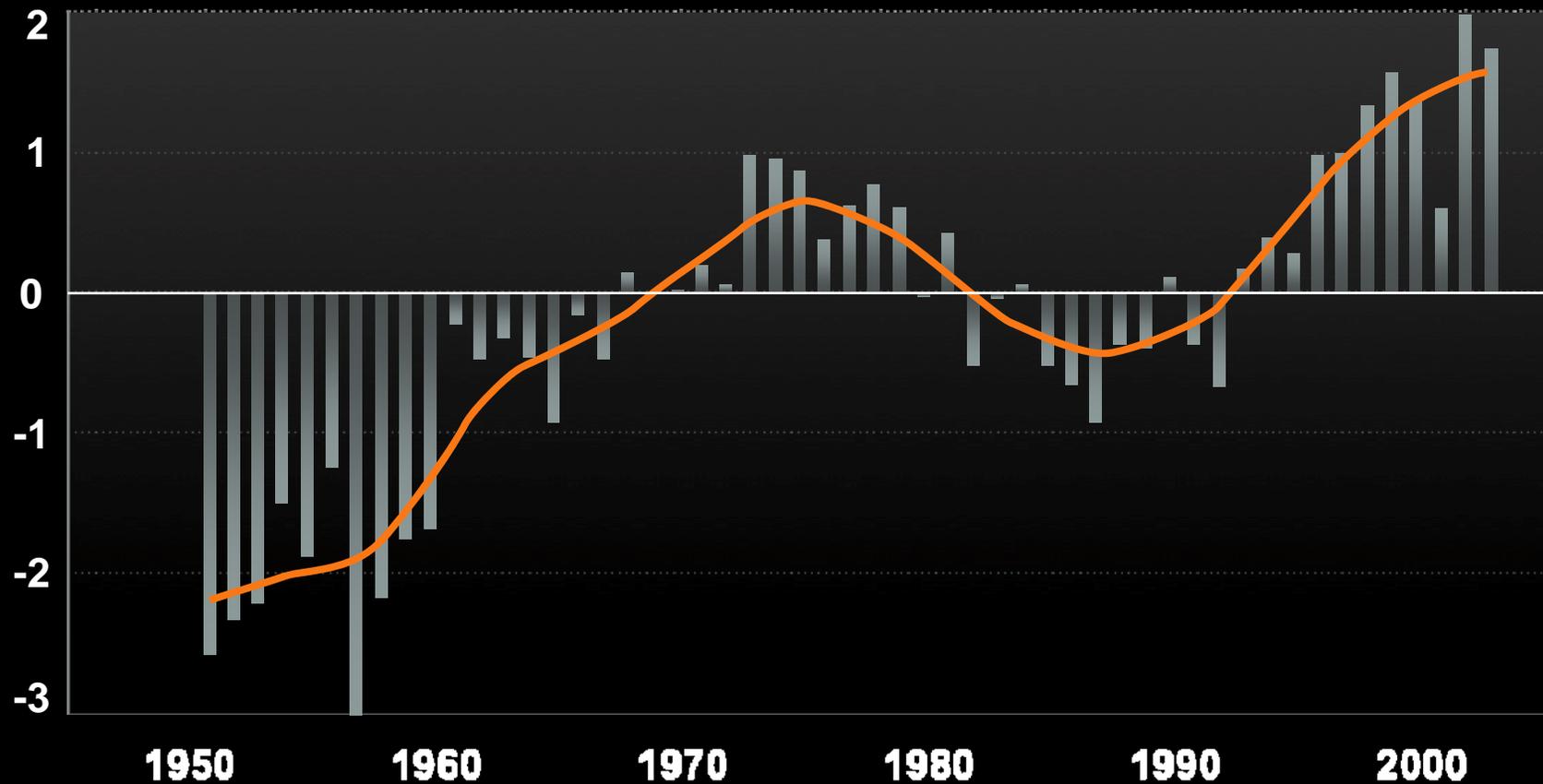




Structures Already At Risk from Inundation

- Residential homes
- Power Generation Plants
- Sewage Systems
- Cemeteries
- Recreational Areas
- Community Centers/Libraries
- Government agency buildings (i.e., emergency management office in Salinas; police stations in Fajardo)
- Schools
- Hospitals

Increase in Heavy Precipitation Days Worldwide



Source: Alexander, L. V., et al. (2006), Global observed changes in daily climate extremes of temperature and precipitation, *J. Geophys. Res.*, 111, D05109, doi:10.1029/2005JD006290

Puerto Rico has already
experienced a 37% increase in the
amount of very heavy precipitation
from 1958-2007

Source: NOAA – US Global Chang Research Program

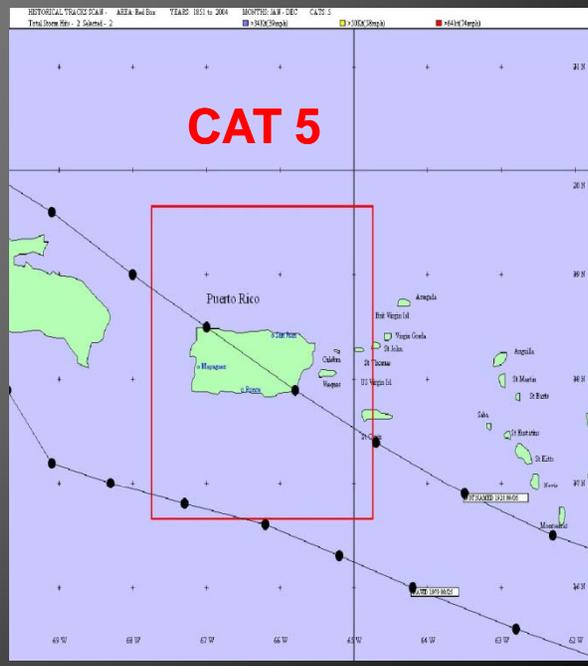
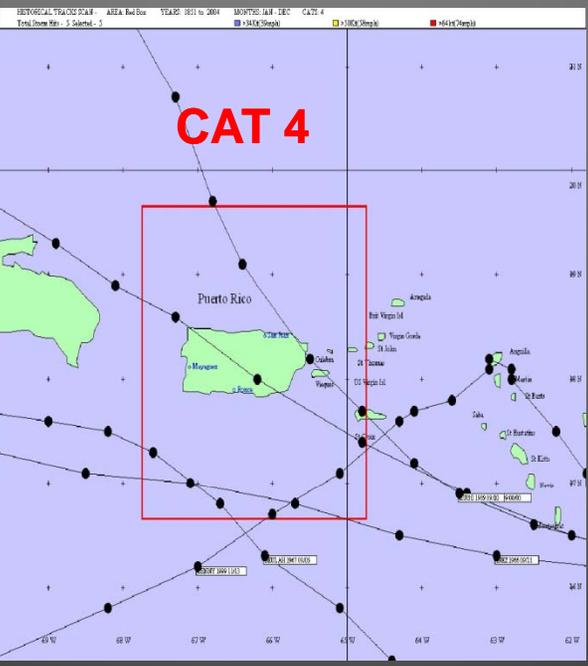
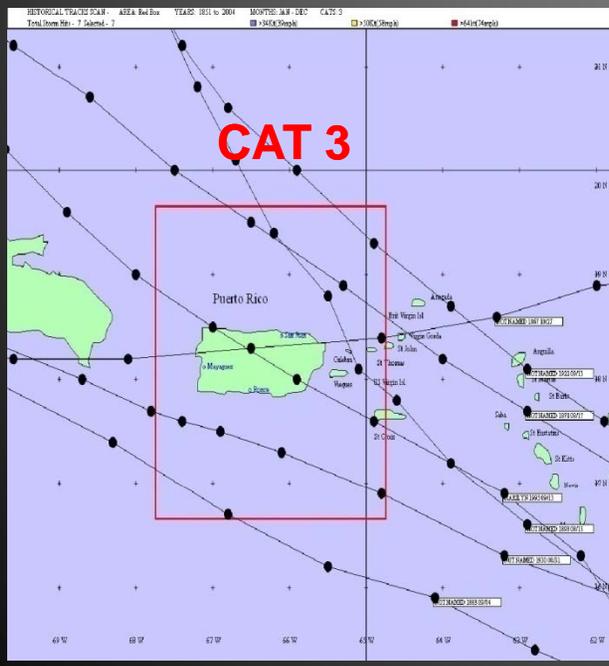
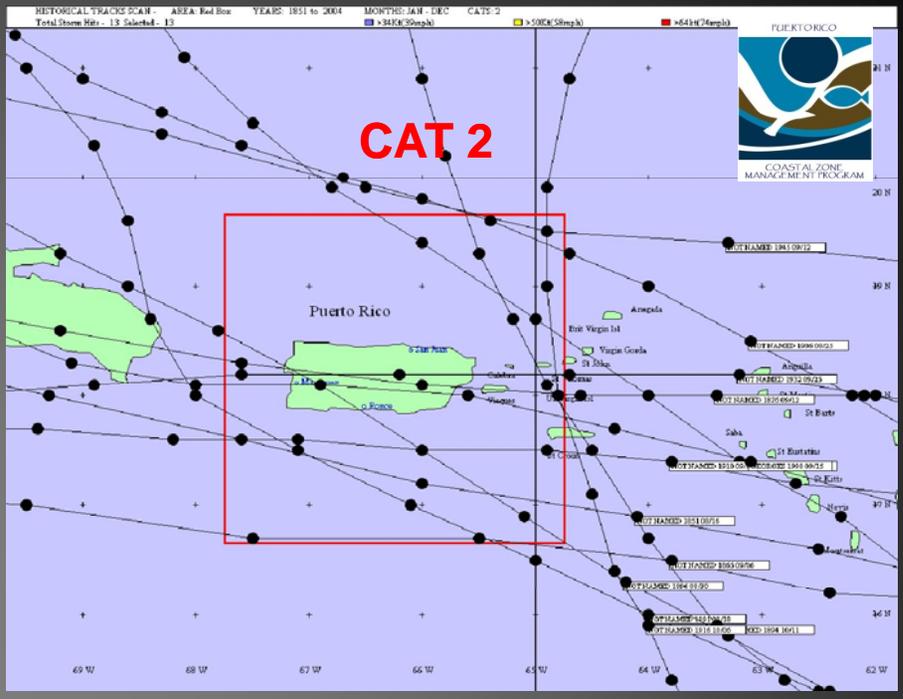
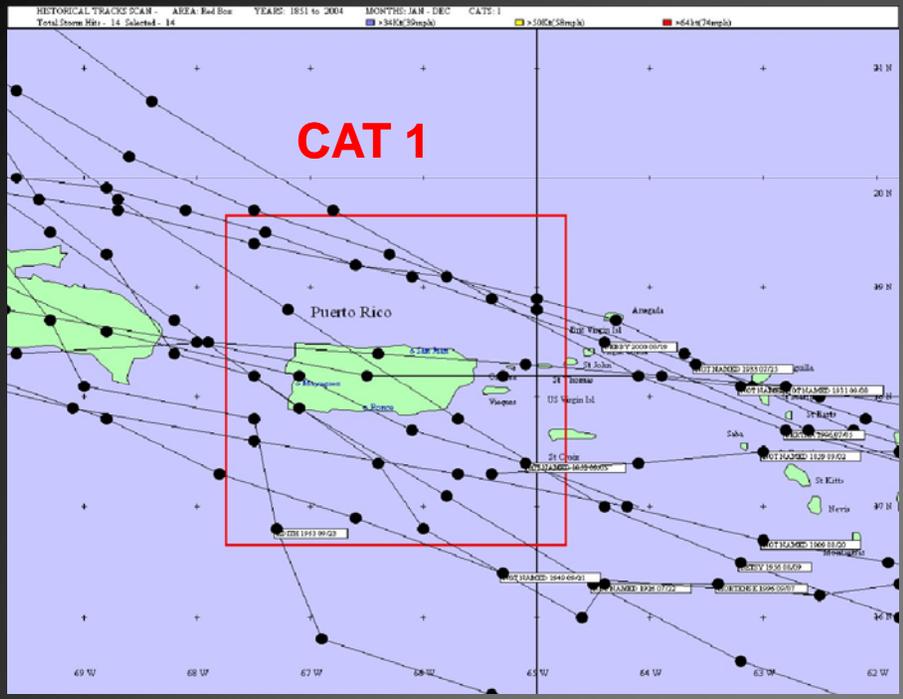


Fajardo – Lluvias del 17 de abril de 2003









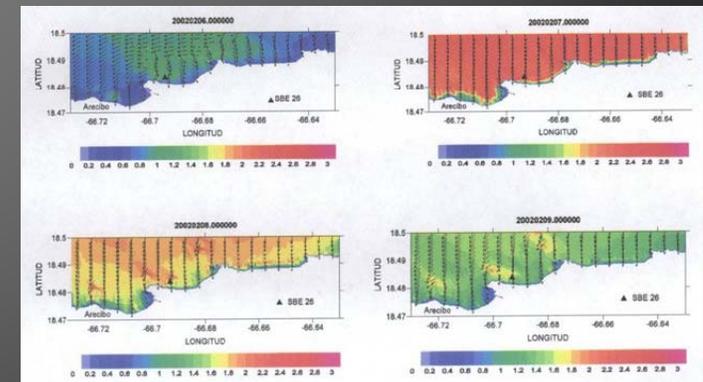
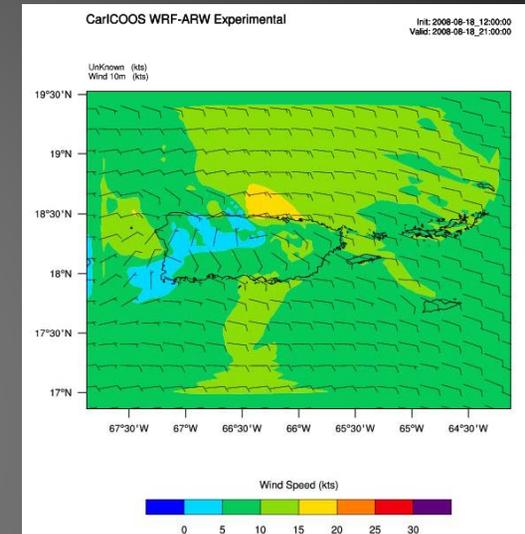






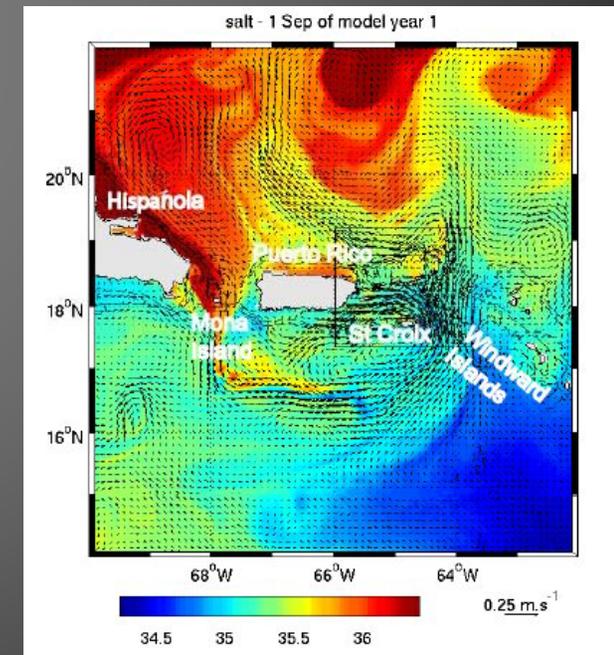
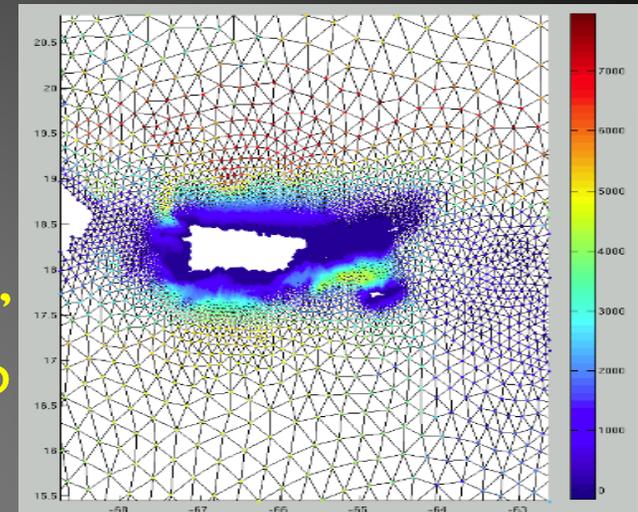
MODELING ASSETS

- CaRA and UPRM have jointly established the Alliance for Numerical Modeling and Coastal Forecast. **The PRCMP of DNER has contracted the Alliance to perform Coastal Zone inundation modeling using ADCIRC, SWAN and COULWAVE.**
- Coastal winds, WRF J. Gonzales-CaRA/UPRM, S. Strippling NWS-SJ)
- Coastal waves, SWAN (C. Anselmi, CaRA-UPRM, J. C. Ortiz –UniNorte

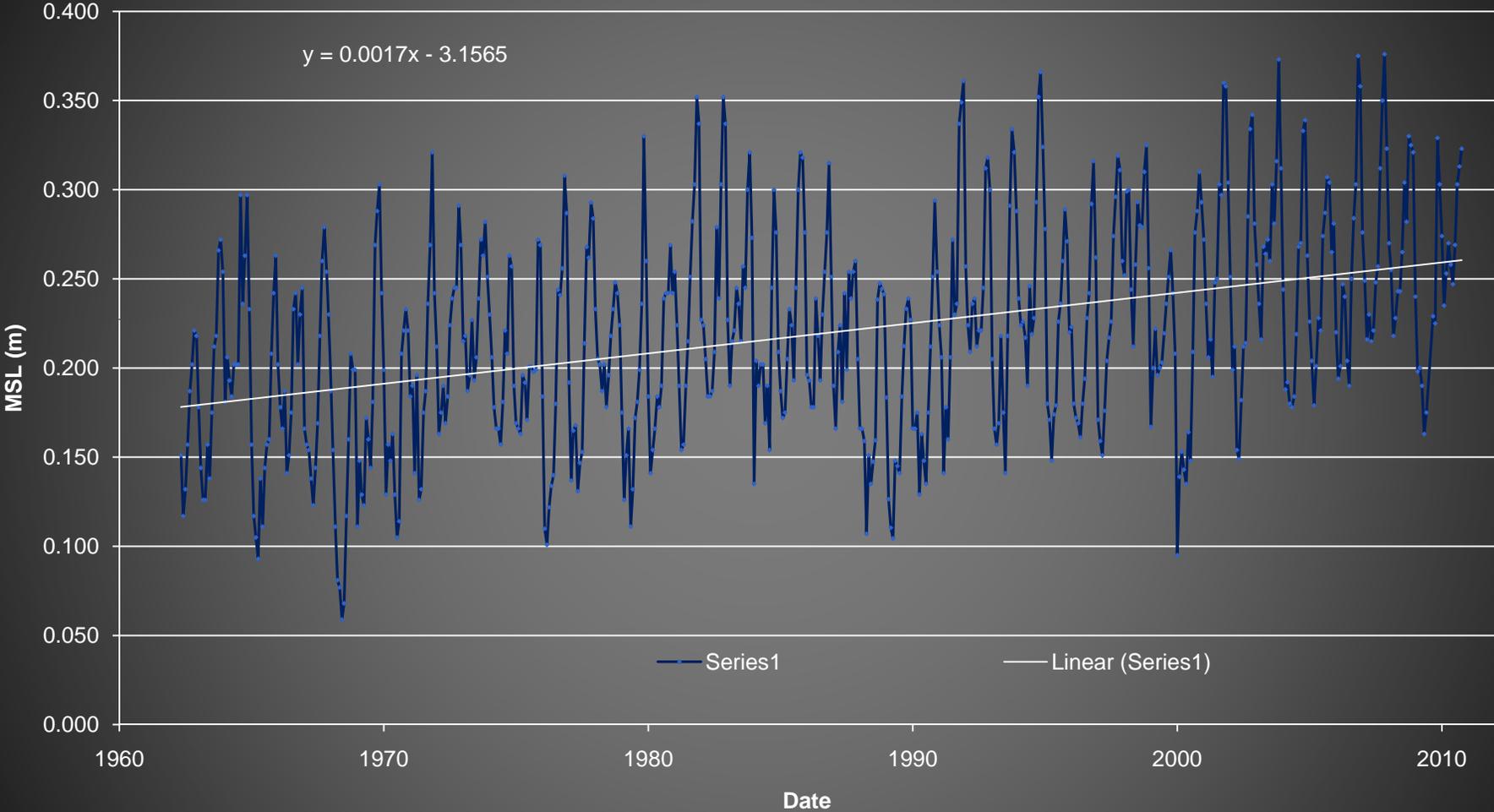


MODELING ASSETS (cont.)

- Storm surge-inundation ADCIRC (J. Gonzalez, CaRA-UPRM, A. Mercado-UPRM, B. Blanton-Renaissance Institute, and Ernesto Díaz, DNER Coastal Management Office.)
- Coastal currents, ADCIRC (J. Capella-CaRA, Dave Hill,- Penn State)
- Offshore currents (HYCOM/ROMS)
L. Cherubin-RSMAS, N. Idrissi-UVI),
IAS/NCOM (D. Ko-NRL)

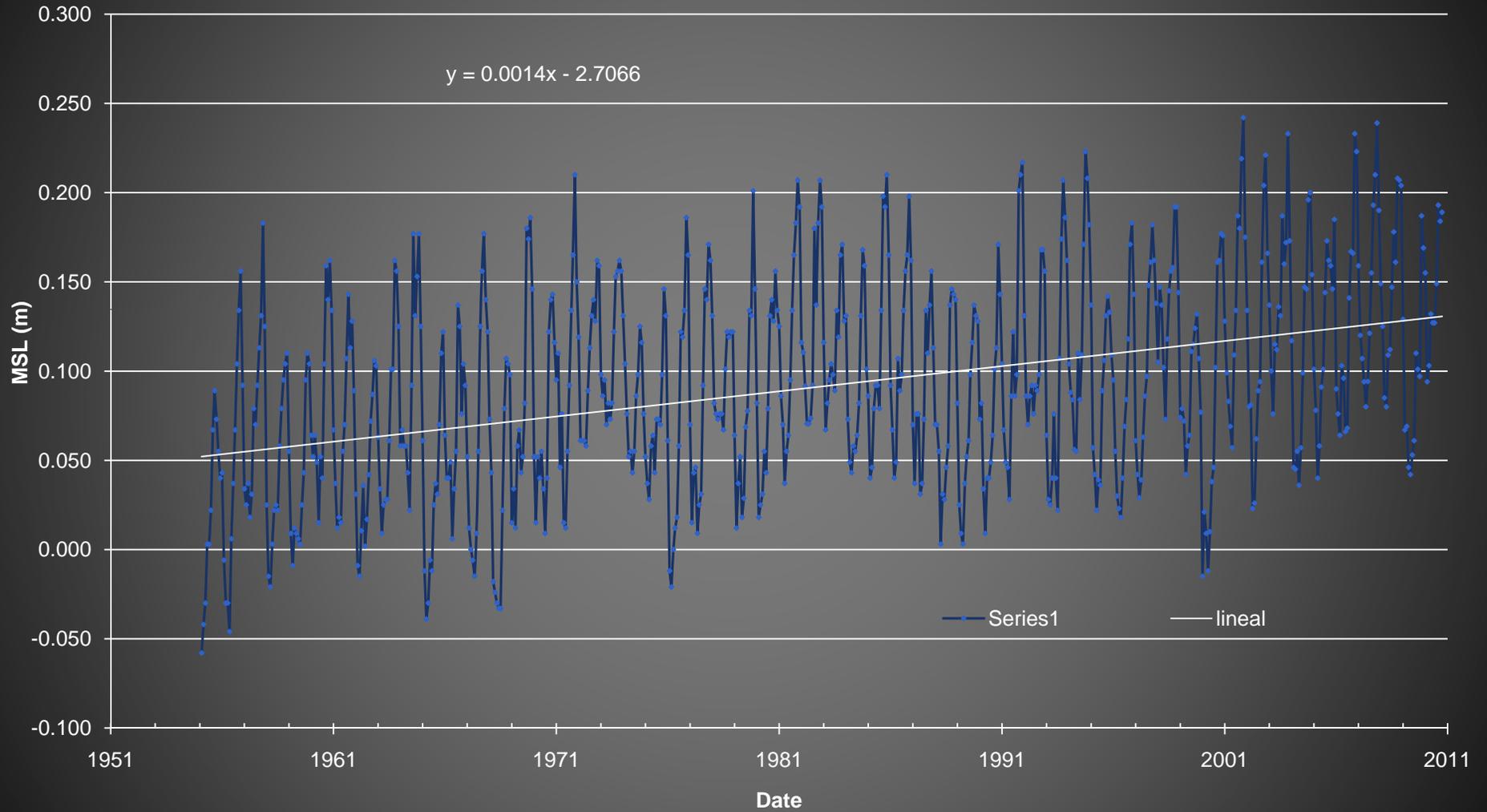


San Juan Monthly Mean Sea Level 1962-2010



0.414m 2100

Magueyes - Monthly Mean Sea Level 1955-2008



0.256m 2100

FINAL REPORT

A geomorphologic assessment at selected beach sites using imagery analysis (1936-2007) and beach profiling techniques (2010); as a tool to define coastal indicators and management applications.

Playa Vega Baja, Playa Piñones, Loiza, Playa Fortune, Playa Punta Santiago, Humacao, Playa Salinas, Salinas Mayagüez

Prepared by Maritza Barreto, Ph.D
12/31/2010





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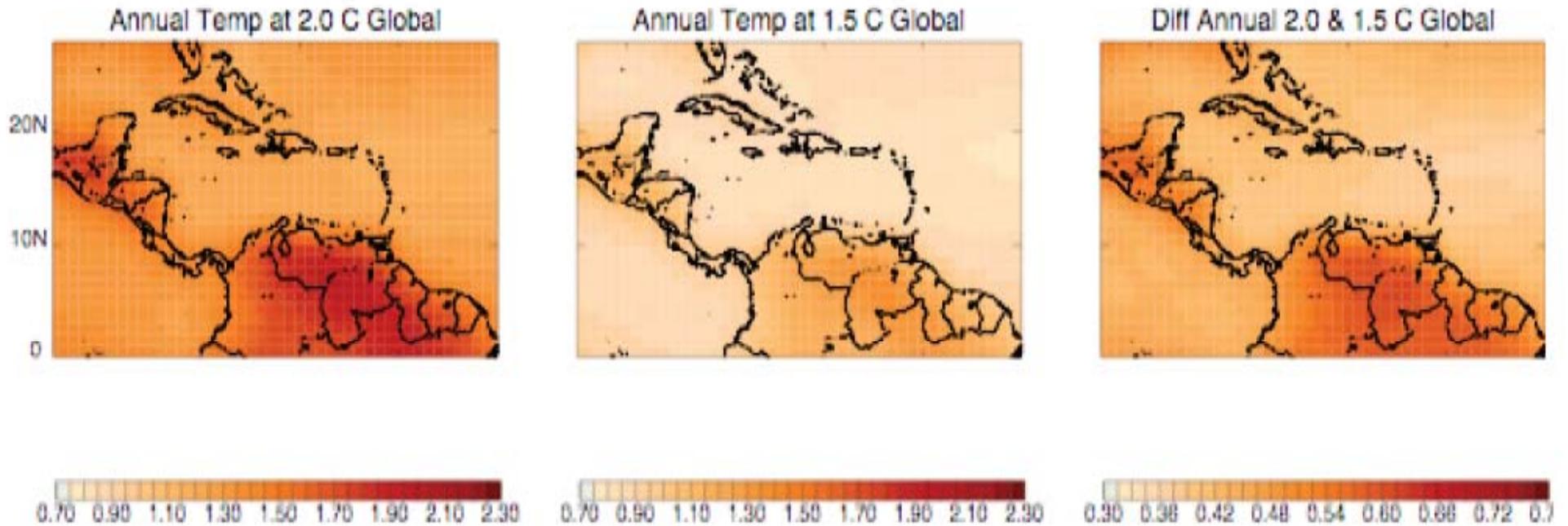
Fuente: DRNA, Image 2007
Rodríguez Lyzaida, 2010

Our “First Lines of Defense” are Disappearing

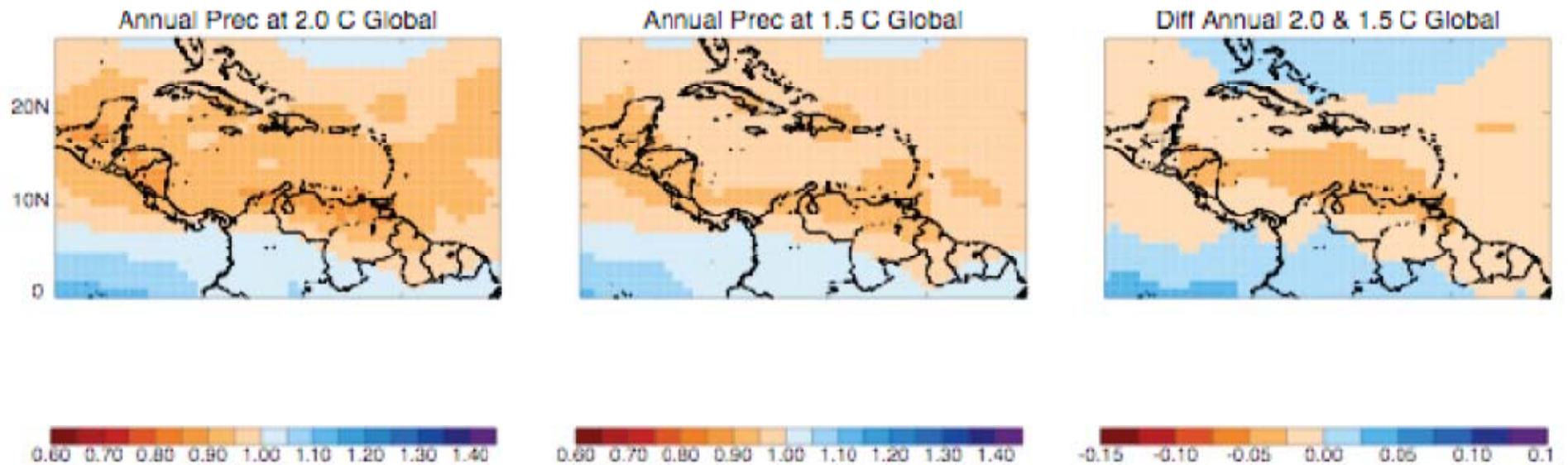


POSSIBLE FUTURE CLIMATE CONDITIONS – CHALLENGES FOR THE COASTS

Simpson et al. Figure 1: Changes in regional average annual temperatures compared to present day values at thresholds of 2.0 ° C and 1.5 ° C and differences between the two; all values in Celsius; note differences in the scales.



Simpson et al 2009 figure - fractional changes in total annual rainfall; reds indicate drying, blues increased rainfall; note differences in the scales.





Winter Swells and Nor'easters

Under higher-emissions scenario, between 5 and 15 percent more late-winter storms will move far enough north to affect the Northeast (about one additional late-winter storm per year). Lower emissions show little change in the number of nor'easters that strike the NE, therefore little change in PR winter swells.

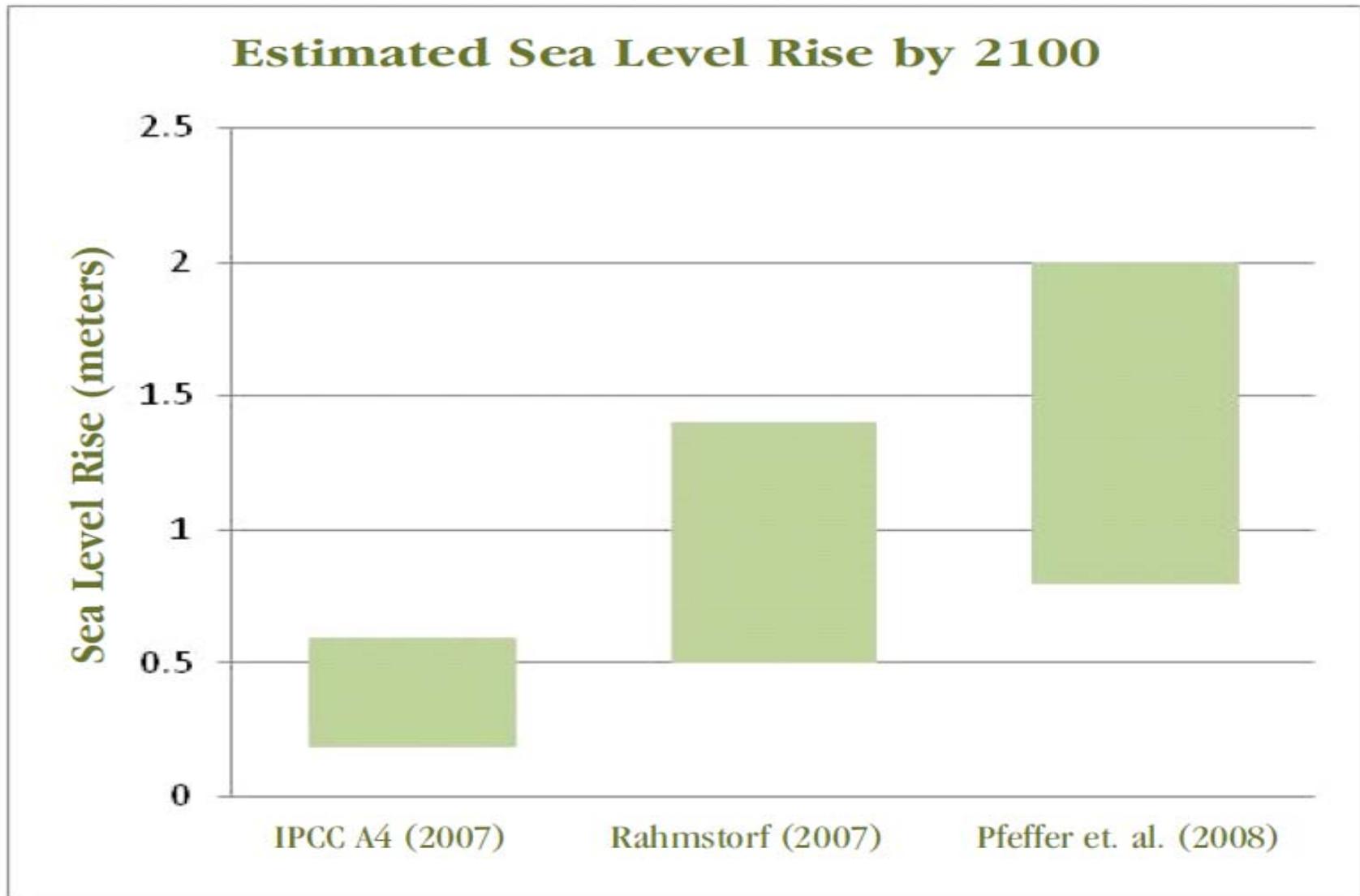
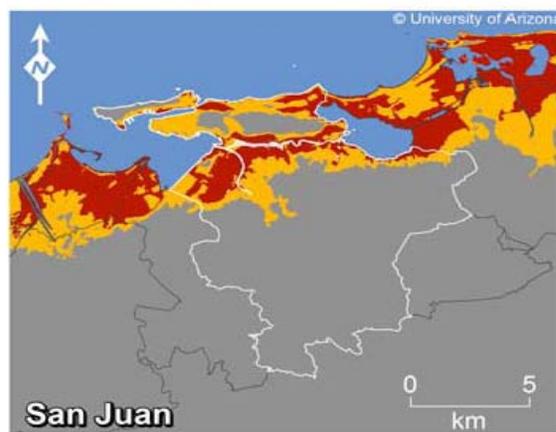
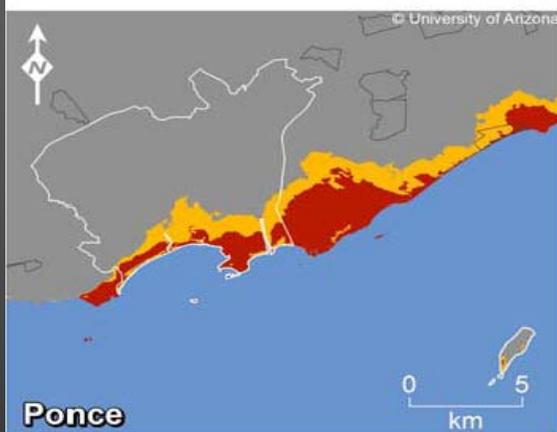
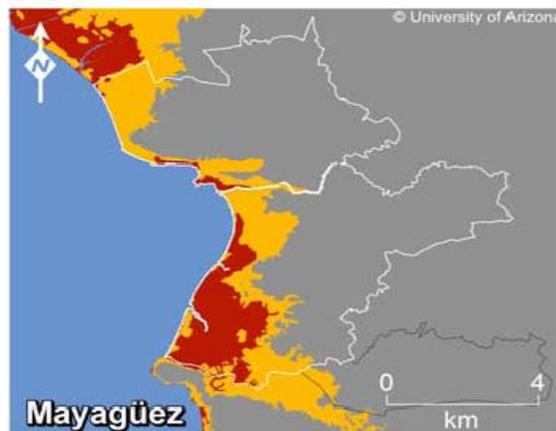
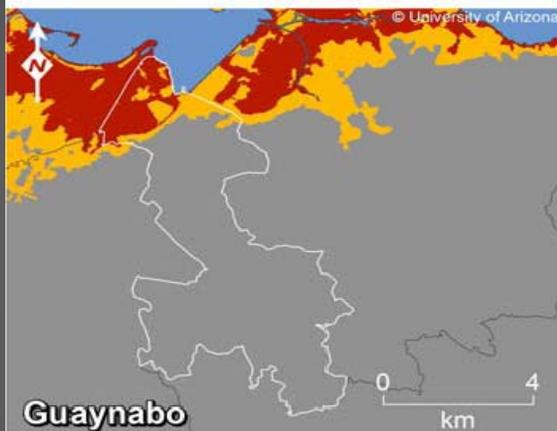
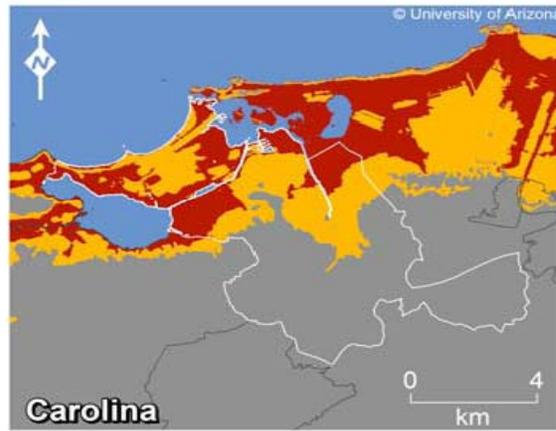
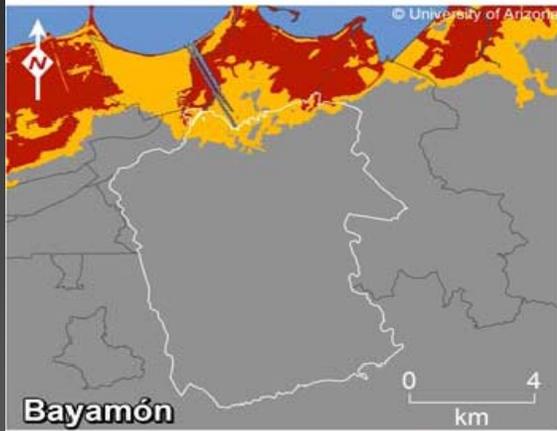


Figure 1. Comparison of recent estimates of sea level rise in 2100, relative to 1990 levels.

Inundation Mapping Efforts in Puerto Rico*

- FEMA/Dewberry SLR Advisory Layer (complete but distribution unclear)
- University of Arizona – Department of Geosciences (Weiss and Overpeck) (complete and available for use)
- Citizens of the Karst (NGO)
- CariCOOS – Jorge Capella SLR shapefile (2010)

* That we know about specific to climate change

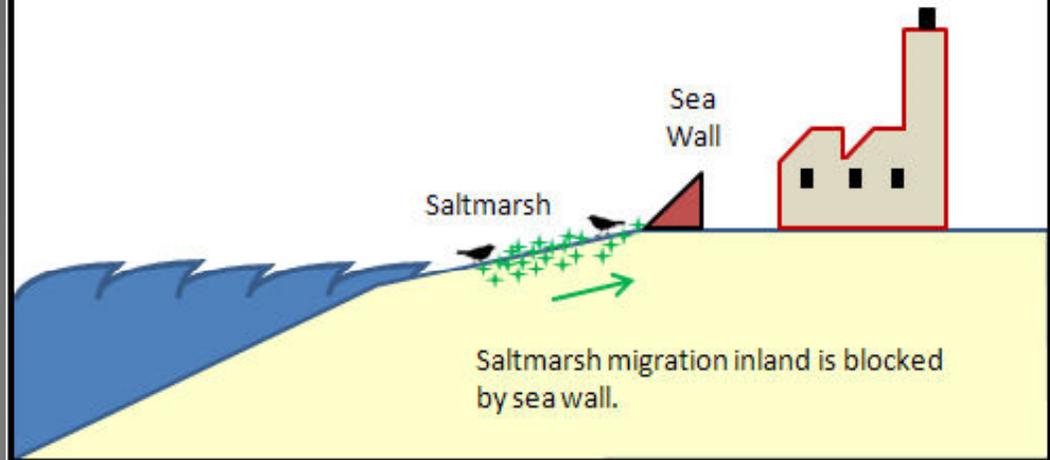


■ ≤ 1 m
 ■ ≤ 6 m
 municipal boundary
 land
 waterbody

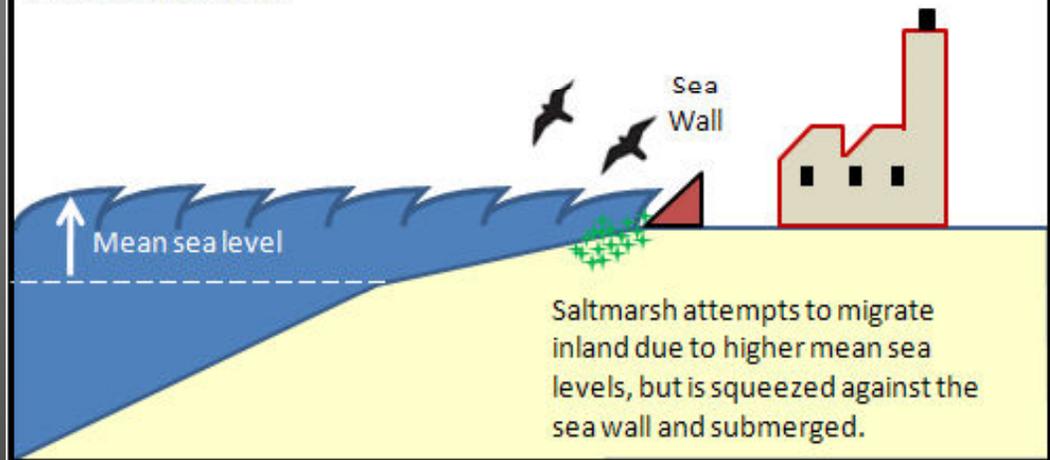
Climate Change impacts on wetlands



Current Situation

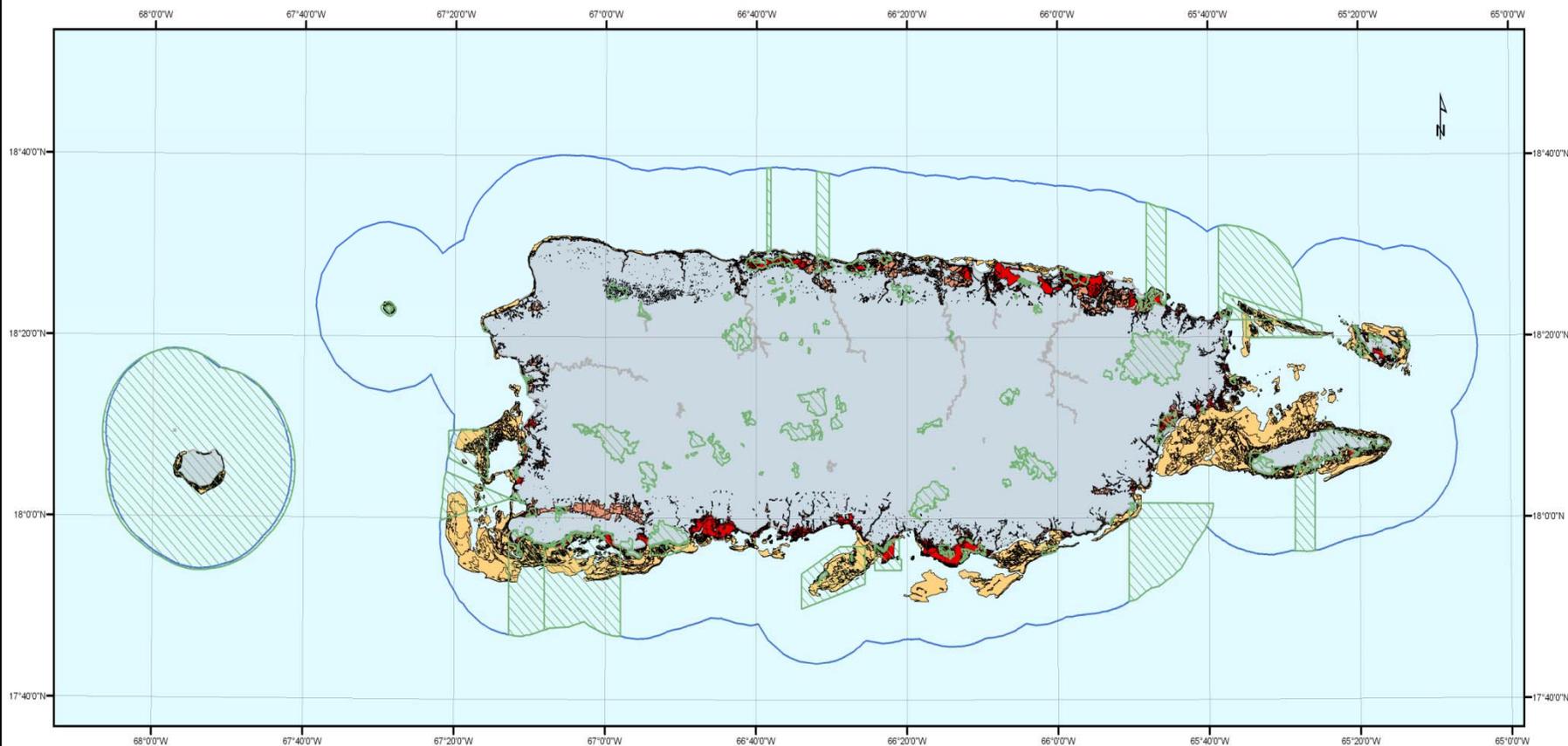


Future Scenario



Leyenda - Map key:

- | | | |
|----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  Humedales palustres - Palustrine wetland |  Humedales estuarinos - Estuarine wetland |  Límite de las aguas territoriales de Puerto Rico (9 millas náuticas) - Coastal zone maritime boundary (9 nautical miles) |
|  Áreas Naturales Protegidas - Natural Protected Areas |  Humedales marinos - Marine wetland | |



Fuente de información - Source:
 Departamento de Recursos Naturales y Ambientales
 Wetlands Inventory
 NOAA Benthic Mapping

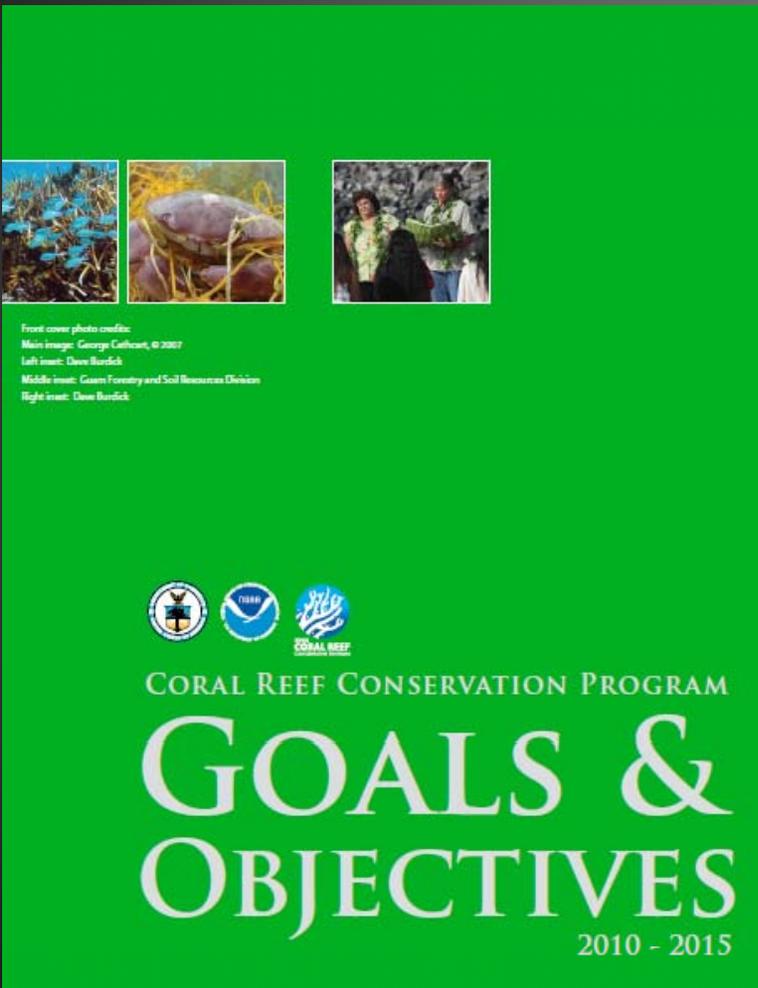
Humedales protegidos de Puerto Rico Protected wetlands of Puerto Rico

Departamento de Recursos Naturales y Ambientales
 Programa de Manejo de la Zona Costanera





Major Coral Reef Stressors



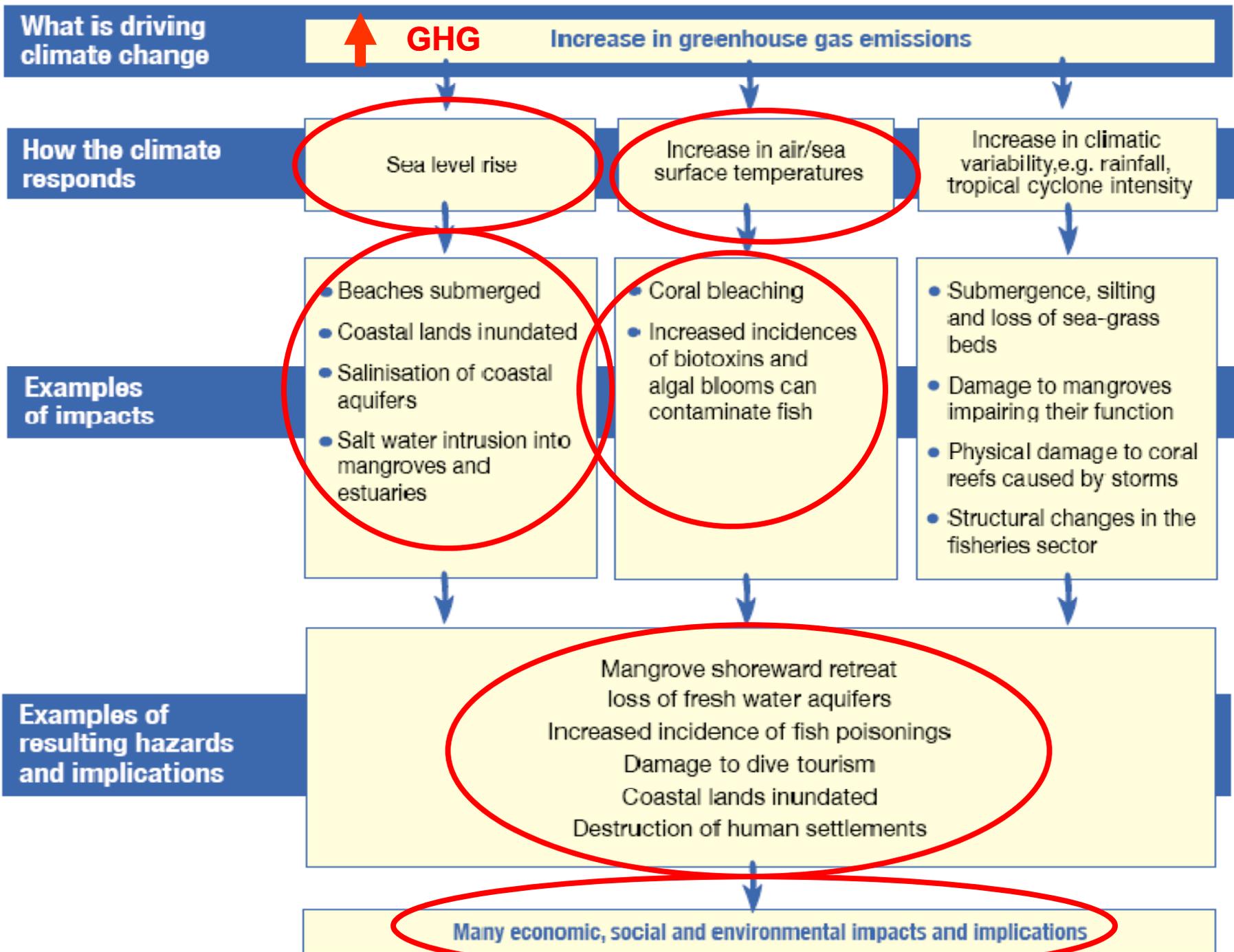
- **Climate Change**
- Land-based Sources of Pollution
- Fisheries Impact
- Disease
- Recreational Overuse
- Lack of Awareness

Climate Change impacts on coral reefs

Climate change impacts are identified as the greatest global threats to coral reef ecosystems:



- Bleaching
- Disease and Mortality
- Ocean acidification



OPTIONS FOR COASTAL MANAGEMENT

Adaptive responses:



Adapting to CC-SLR in Puerto Rico

1. RETREAT

New vs. Existing structures

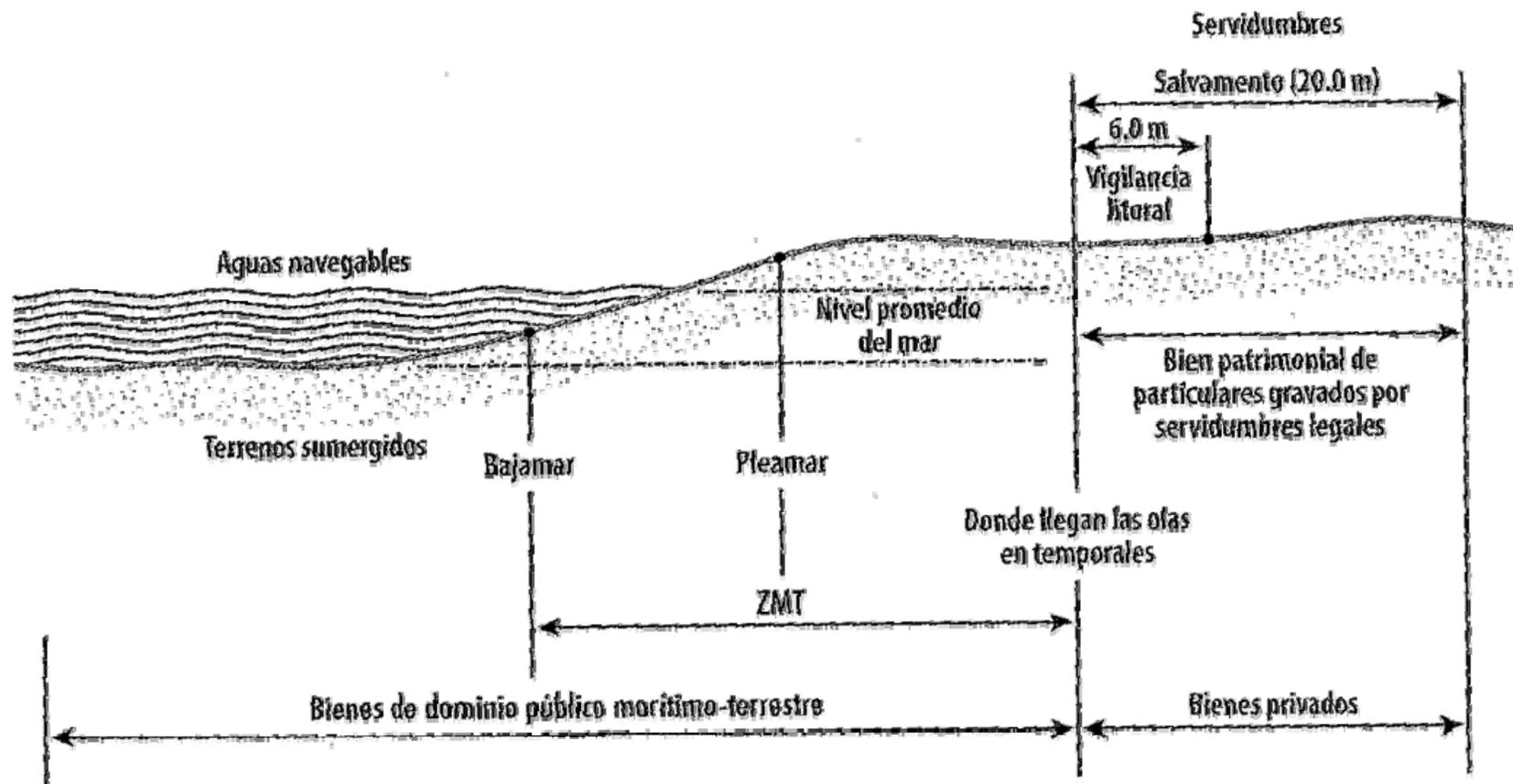
2. ACCOMMODATION

- Water coastal dependant structures
- Port operations, airports, public infrastructure, access roads

3. PROTECTION

Structural, non-Structural
and integrated solutions





Source: Lugo et al. 2004. Cartilla de la Zona Marítimo-Terrestre, 18 (1-3): p. 22





RETREAT

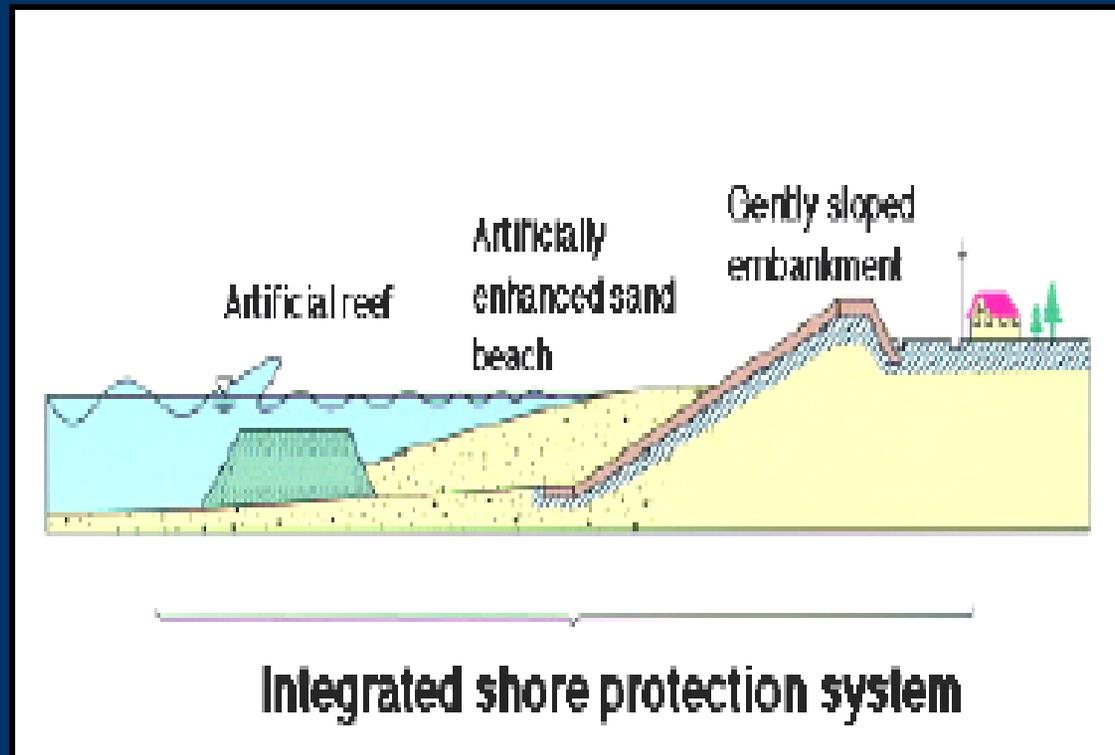


ACCOMODATION



ACCOMODATION

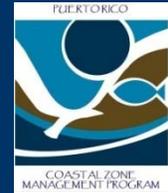
PROTECTION STRATEGIES:



- Coral reefs and dune systems protection
- Wetlands protection, restoration and enhancement
- Artificial reefs
- Integrated options

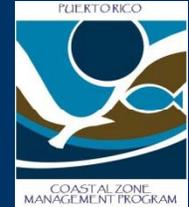


COASTAL MANAGEMENT CHALLENGES FROM CLIMATE CHANGE



- Perception that the coasts should be static
- Perception that there is no scientific consensus on climate change
- Lack of awareness of role/responsibility of coastal managers and resource users
- Incremental/uncertain risk gets lost amid other immediate, concrete issues
- Lack of perfect information
- Property Rights
- Politics
- Planning - Adaptation works best at the local level



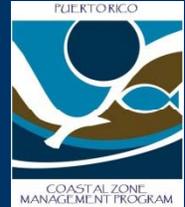


LOW-HANGING FRUIT

- Implement hazard mitigation strategies laid out in municipal hazard mitigation plans
- Require each agency to conduct vulnerability assessments and integrate climate change into their work
- Purchase coastal lands that serve as buffers or dissipate wave energy as well as potential wetland advancement areas
- More research and high resolution mapping/modelling



MORE CHALLENGING ADAPTATION STRATEGIES



- New setbacks based on SLR projections
- New building codes
- New insurance requirements for DRR
- Local planning for adaptation
- Large-scale flood reduction programs
- Planned retreat of certain areas and communities
- Soft and hard shoreline protection structures



Climate Change in the Caribbean: Puerto Rico & the U.S. Virgin Islands

November 15-16, 2011

San Juan, Puerto Rico





Gracias!