Functionality of Coastal Navigation with Rise in Sea Level

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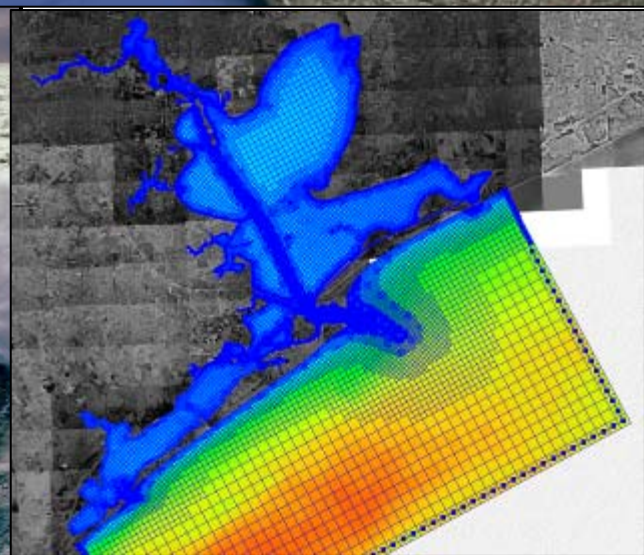

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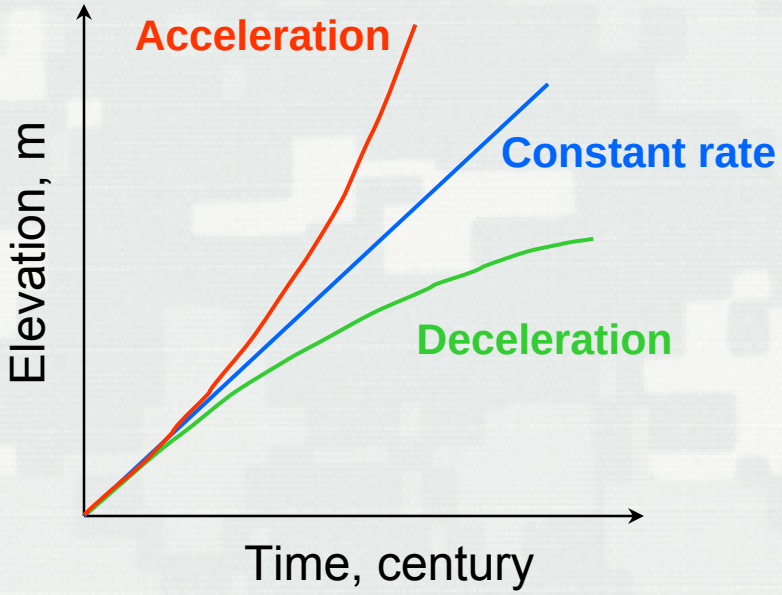
Coastal Navigation With Sea Level Rise

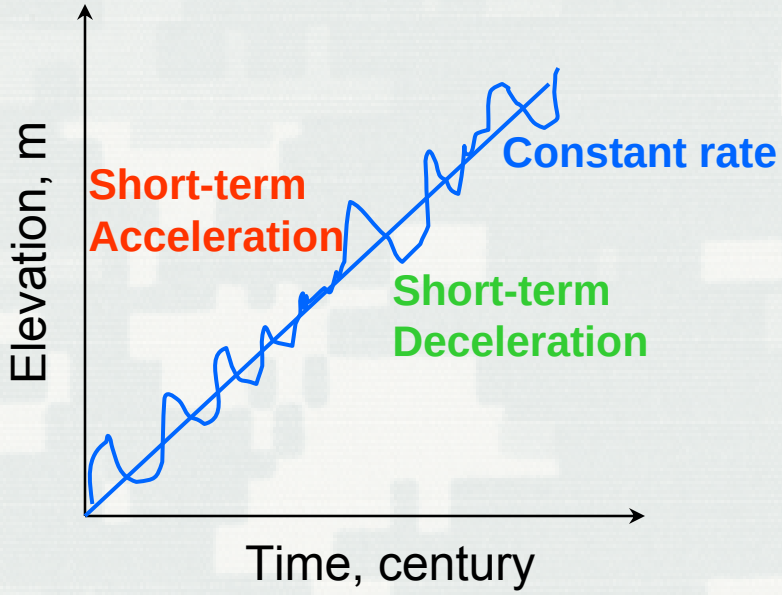
Overview; how to make navigable inlets more resilient to SLR?

1. Background on Sea Level Rise (SLR)
2. General consequences of SLR
3. US Army Corps of Engineers guidance
4. Anticipating SLR in coastal navigation
   a. *Jetties and navigation channels*
   b. *Tidal inlets and adjacent beaches*
   c. *Barrier islands and estuaries*
   d. *Dredged material placement sites*
   e. *Navigation infrastructure*
5. Conclusions and recommendations

1. Background
Terminology

- **SLR** – rise in ocean level
- **Eustatic** or **Global sea level** – world-wide trend in sea level
- **Relative SLR** – rise in water level with respect to land
  (land could be going down, instead of or as well as water level going up)
- **Rate –** distance or elevation over time (e.g., m/century)
- **Time scales of change –** hour, day, season, year, decade, century…



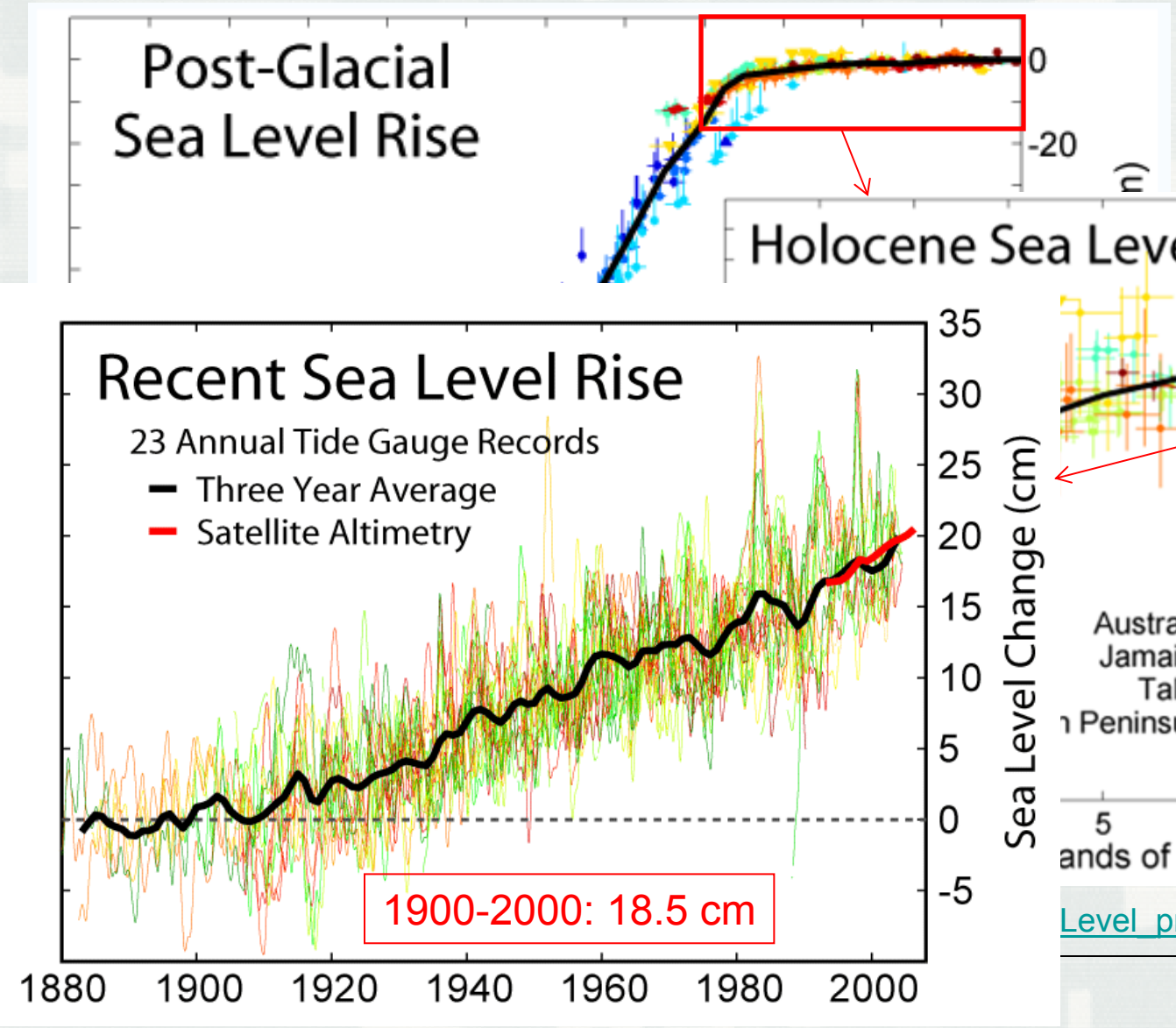


Factors contributing to SLR

1. Global warming → ocean water expanding
2. Ice caps melting
3. Land subsiding (oil, gas, water extraction; sinking on soft substrate; etc.)
4. Coastal crust subsiding
5. Trapping of water in reservoirs behind dams since 1930 has reduced SLR by ~ ¼. (*SLR would have increased had the dams not been built!*)
6. Storm intensity & frequency increasing

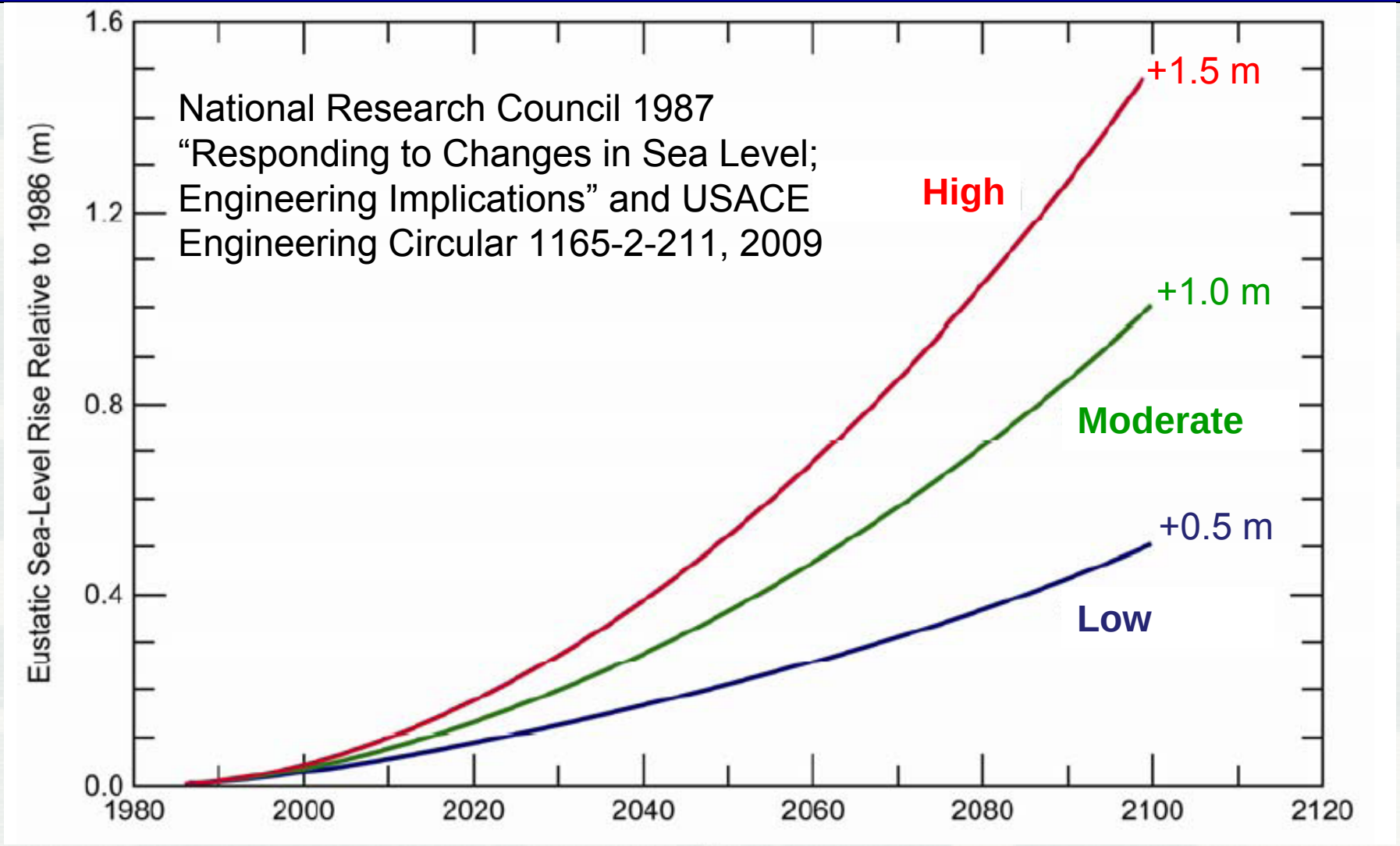
Tide gauges *measure* rate of SLR, ~ 15-30 cm/century on US east coast (0.5 – 1 ft/century)

Global Sea Level – the Big (Long-Term) Picture



Level_png

Global Sea Level – the Future?



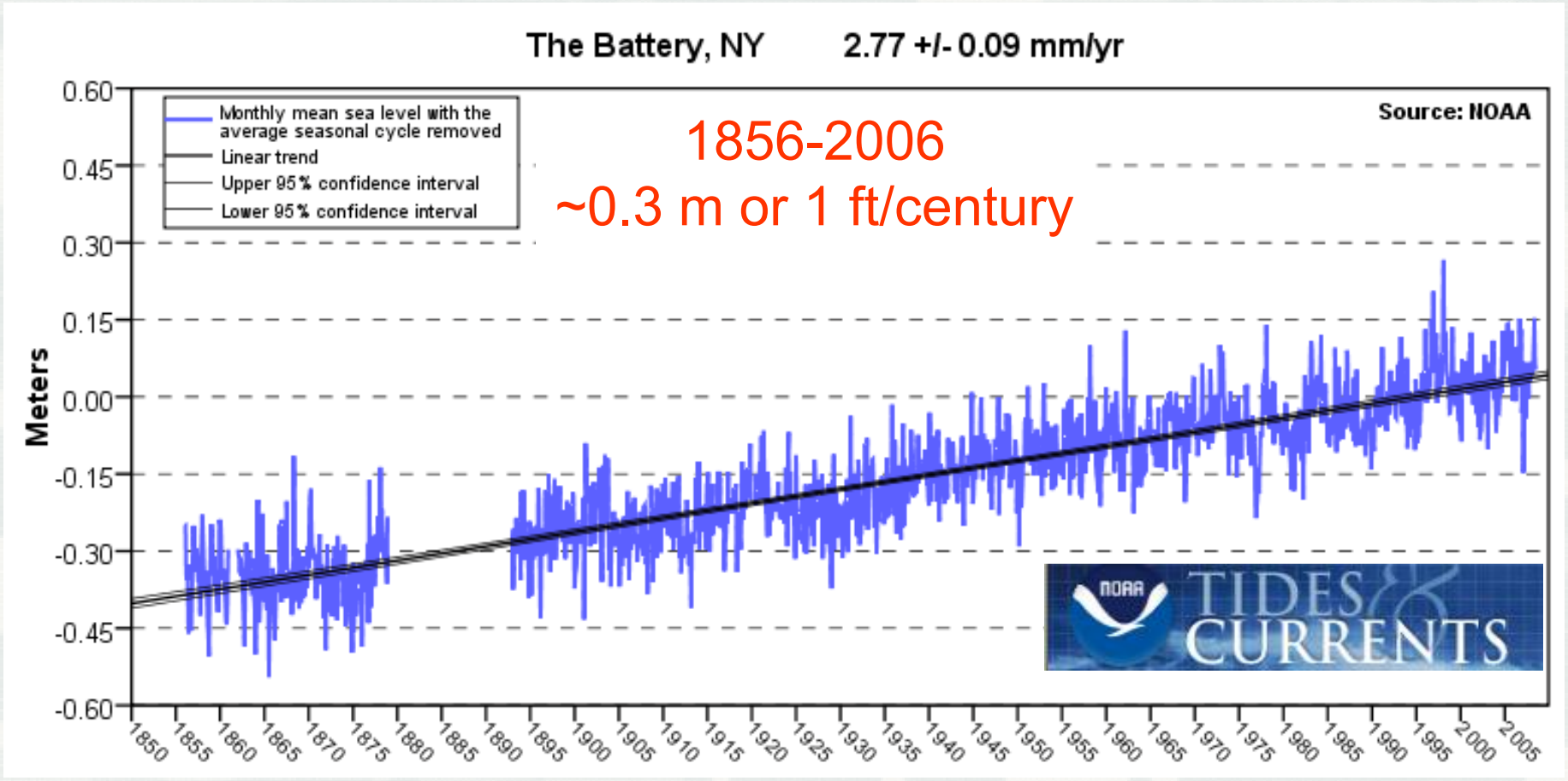
Relative sea level change around the US

Transf

2. General consequences of SLR

- SLR – long-term and gradual damage or change.
- Storm impacts – SLR moves storm intensity further landward.
- Increased vulnerability to storms will increase with SLR – flooding, erosion, & wave forces.
- Direct beach erosion and loss of coastal property by elevated water level and exposure to waves.
- Indirect beach erosion through barrier island migration and interaction with coastal inlets.
- Salinity intrusion in aquifers, up rivers, in estuaries; habitat loss or habitat conversion.
- Altered functioning of navigation jetties.
- Change in sediment pathways at inlets and navigation channels.
- Increased shoaling in navigation channels; offset somewhat by increase in water level and navigable depth.

Example Historical Sea Level Record: The Battery, NY

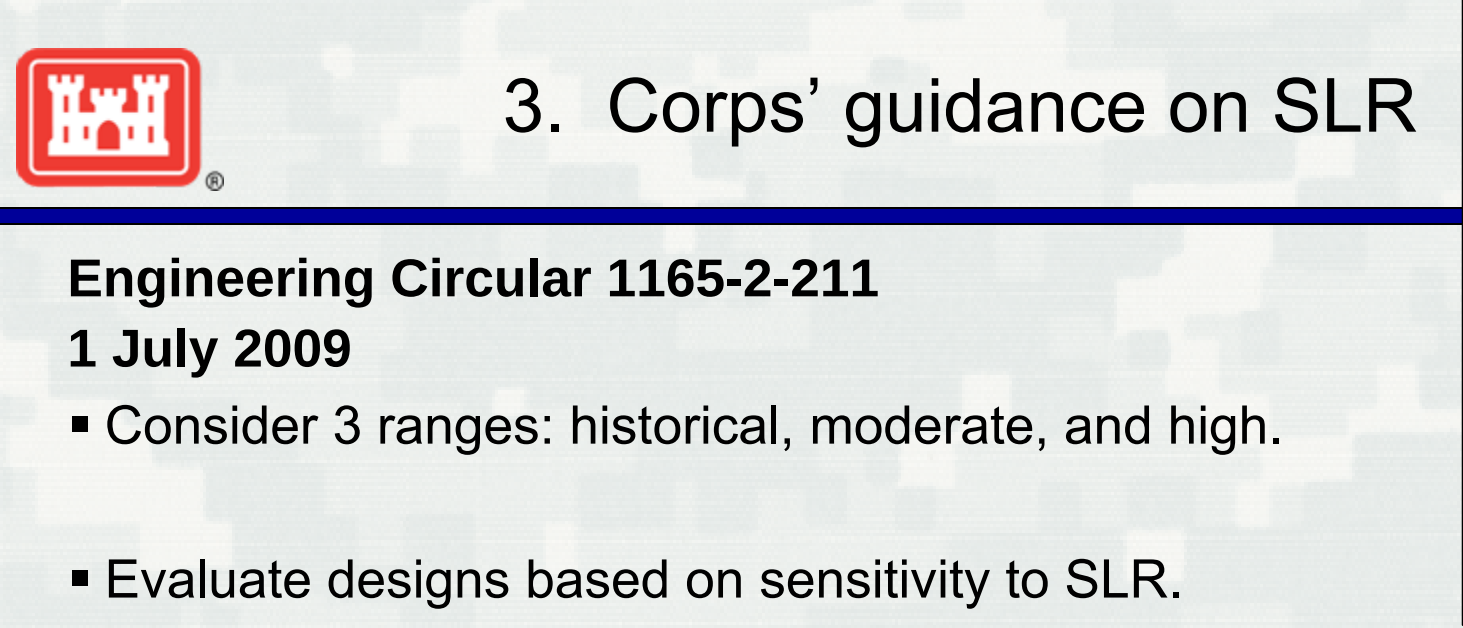


The Battery tide station – at tip of Manhattan facing NY Harbor entrance

3. Corps' guidance on SLR

Engineering Circular 1165-2-211
1 July 2009

- Consider 3 ranges: historical, moderate, and high.
- Evaluate designs based on sensitivity to SLR.
- For alternatives sensitive to SLR, evaluate resulting costs and timing of required rehabilitation as part of each plan.



Department of the Army
U.S. Army Corps of Engineers
Washington, DC 20314-1000

CECW-CE

EC 1165-2-211

Circular
No. 1165-2-211

1 July 2009

EXPIRES 1 JULY 2011

WATER RESOURCE POLICIES AND AUTHORITIES
INCORPORATING SEA-LEVEL CHANGE CONSIDERATIONS
IN CIVIL WORKS PROGRAMS

1. Purpose. This circular provides United States Army Corps of Engineers (USACE) guidance for incorporating the direct and indirect physical effects of projected future sea-level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. Impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs.

2. Applicability. This Circular applies to all USACE elements having Civil Works responsibilities and is applicable to all USACE Civil Works activities. This guidance is effective immediately, and supersedes all previous guidance on this subject. Districts and Divisions shall inform CECW of any problems with implementing this guidance.

3. Distribution Statement. This publication is approved for public release; distribution is unlimited.

4. References. Required and related references are at Appendix A. A glossary is included at the end of this document.

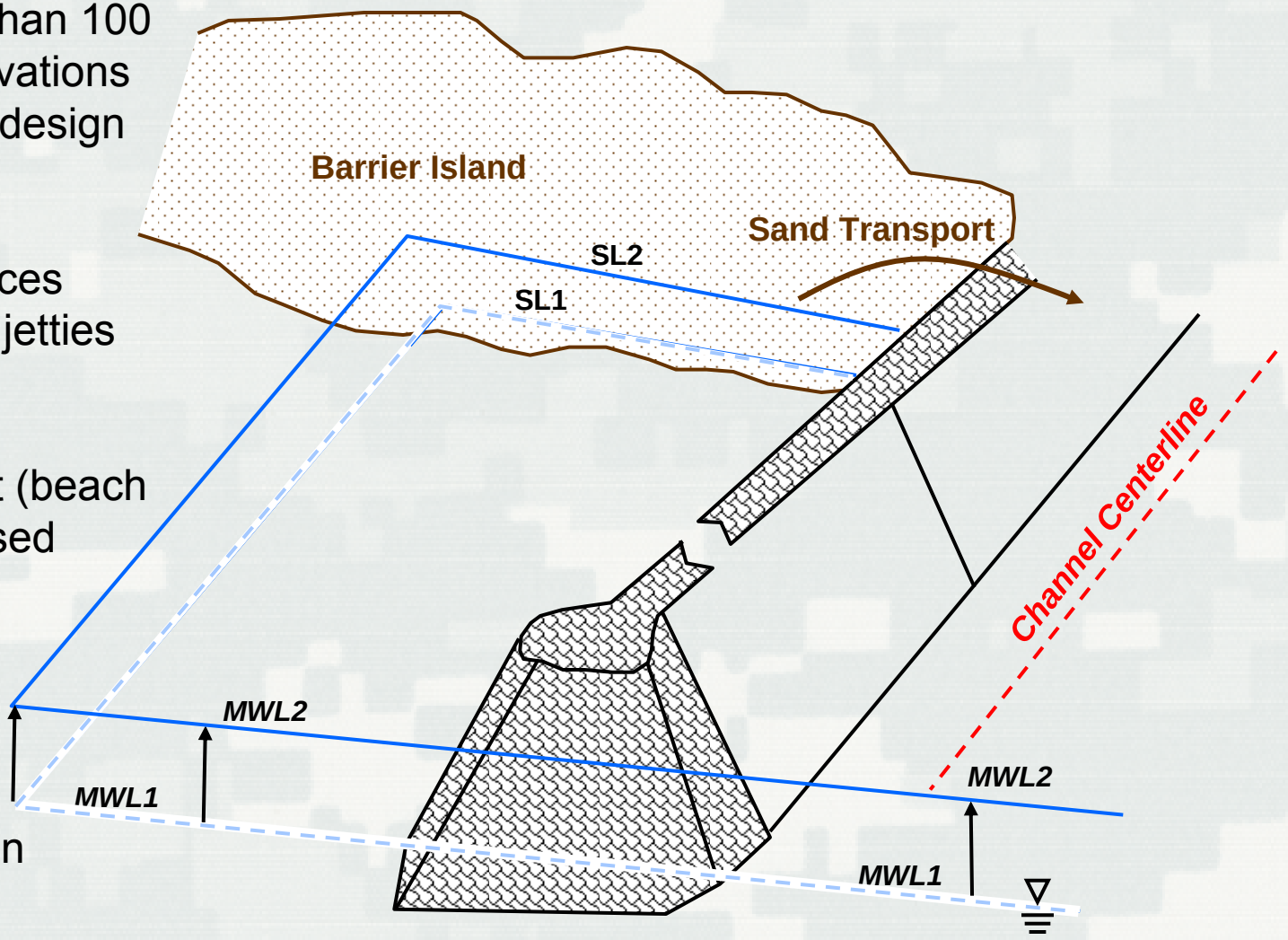
5. Geographic Extent of Applicability.

a. USACE water resources management projects are planned, designed, constructed and operated locally or regionally. For this reason, it is important to distinguish between global mean sea level (GMSL) and local (or "relative") mean sea level (MSL). At any location, changes in local MSL reflect the integrated effects of GMSL change plus changes of regional geologic, oceanographic, or atmospheric origin as described in Appendix B and the Glossary.

b. Potential relative sea-level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Fluvial studies (such as flood studies) that include backwater profiling should also include potential relative sea-level change in the starting water surface elevation for such profiles, where appropriate. The base level of potential relative

4a. Jetties and Navigation Channels

- Many jetties more than 100 years old; crest elevations reduced relative to design water level
- Increased wave forces on inner portion of jetties
- Flanking of jetty by longshore transport (beach erosion, compromised channel)
- Breaching of land or the jetty
- Extreme ship motion in harbors



Jetty Flanking

Photo by N.C. Kraus, 1996, before color film available

Navigation Channels

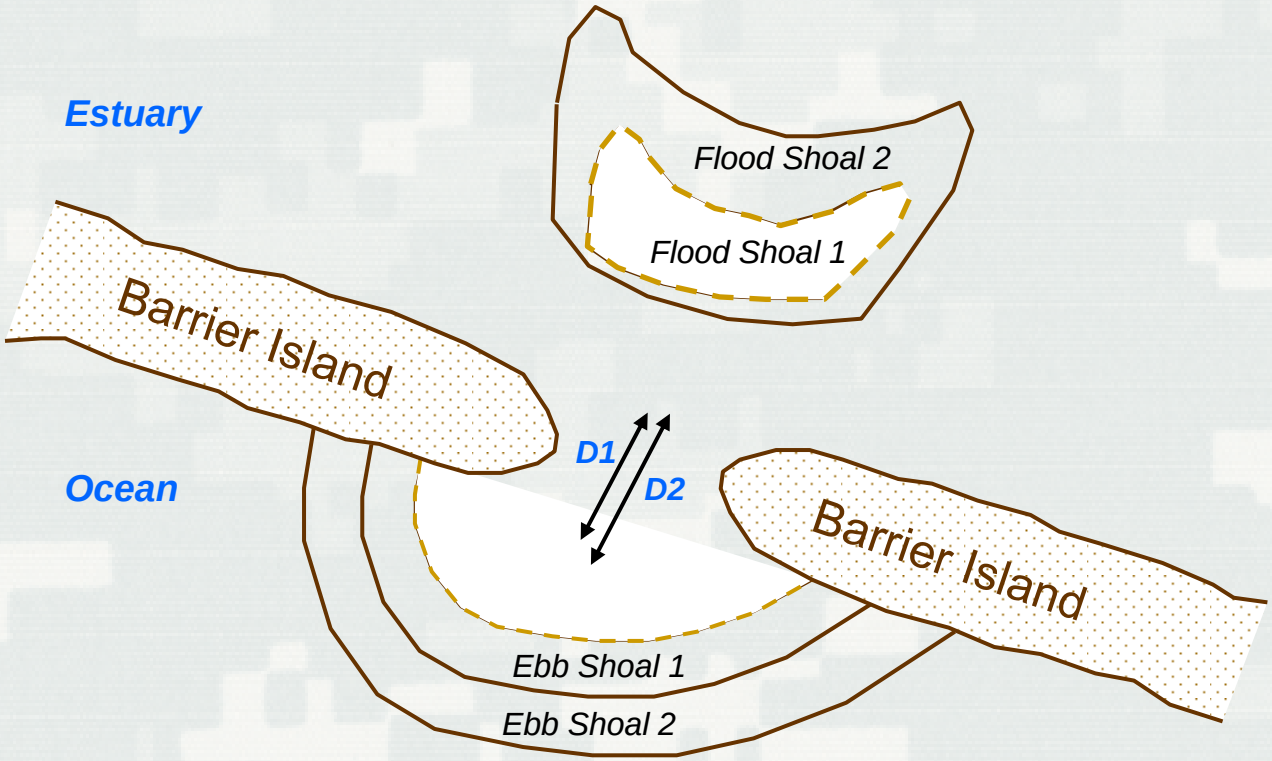
- Increase in navigable depth (benefit)

- Change in shoaling magnitudes and locations
- Salinity intrusion increased into estuary

→shoaling increased if fine-grained flocculation occurs

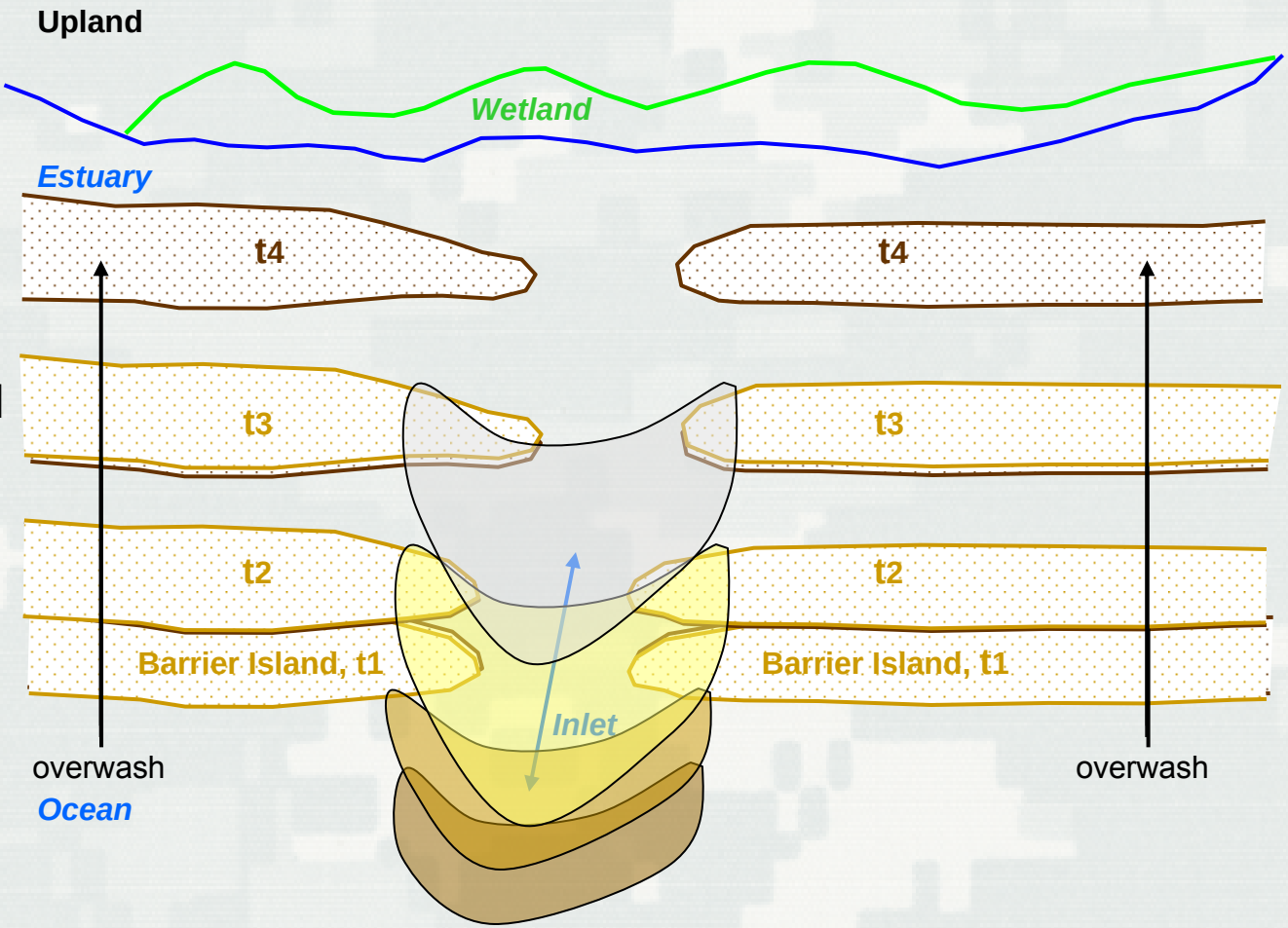
4b. Tidal Inlets and Adjacent Beaches

- Increased tidal discharge → increased inlet shoal volumes
- Shoal sand volumes taken from the adjacent beaches
- Altered sediment pathways; new shoaling patterns



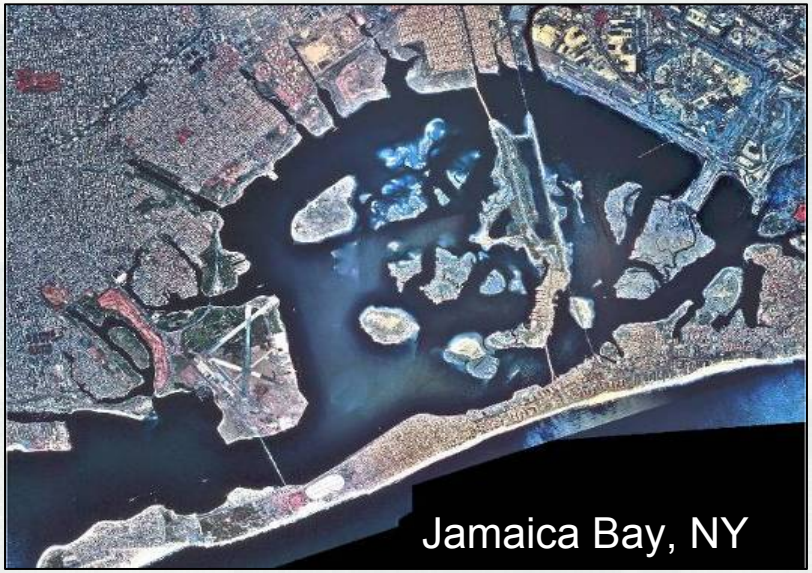
4c. Barrier Islands and Estuaries

- SLR, overwash, and breaching push barrier islands landward
- Estuary area decreases if no space or sediment for growth landward



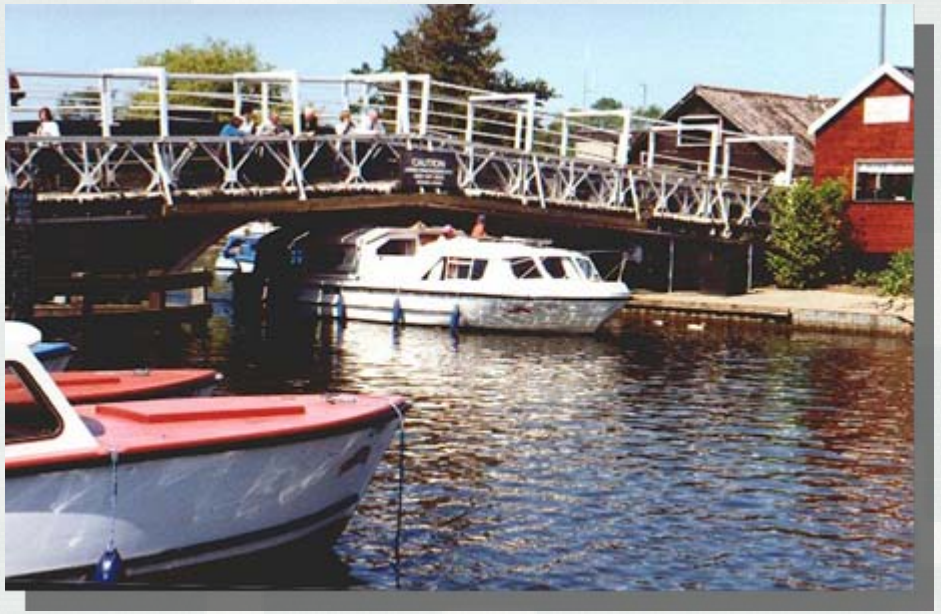
4d. Dredged Material Placement Sites

- Sub-aerial sites may experience reduced capacity and increased waves
- Wetlands may disappear; need to increase beneficial placement; elevate where no space to migrate.
- Sub-aqueous sites increase in capacity?



4e. Navigation infrastructure

- Clearance under bridges reduced
- Port and harbor infrastructure may need to be rehabbed

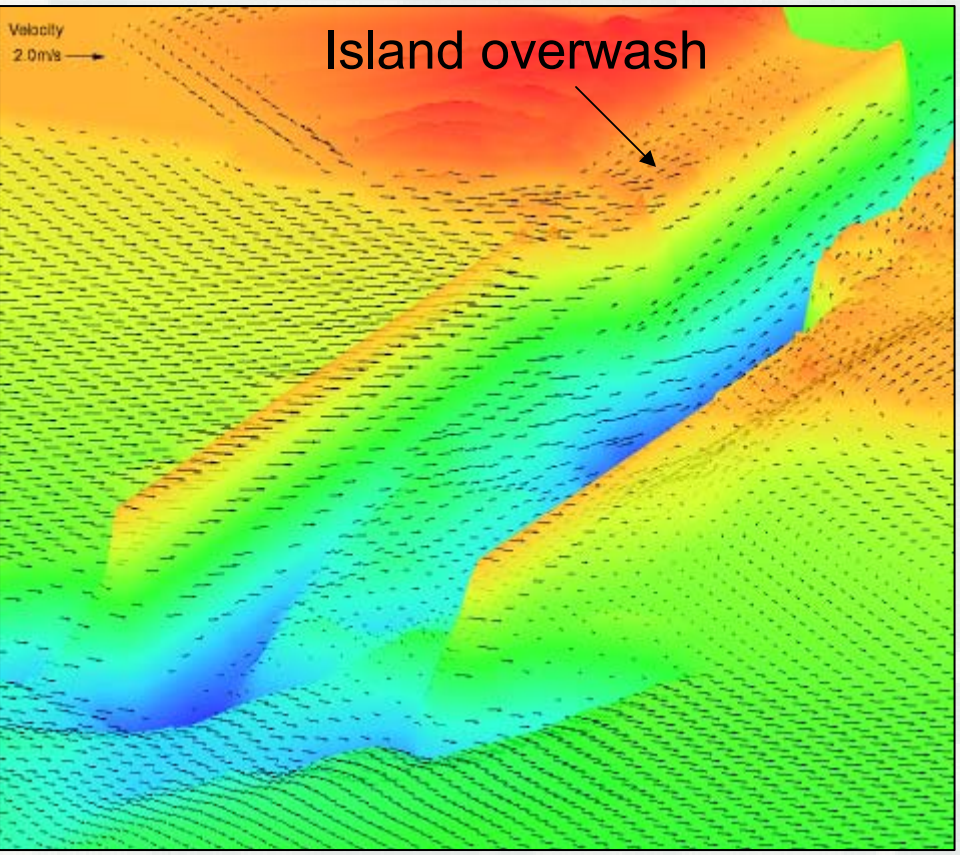


6. Conclusions and recommendations

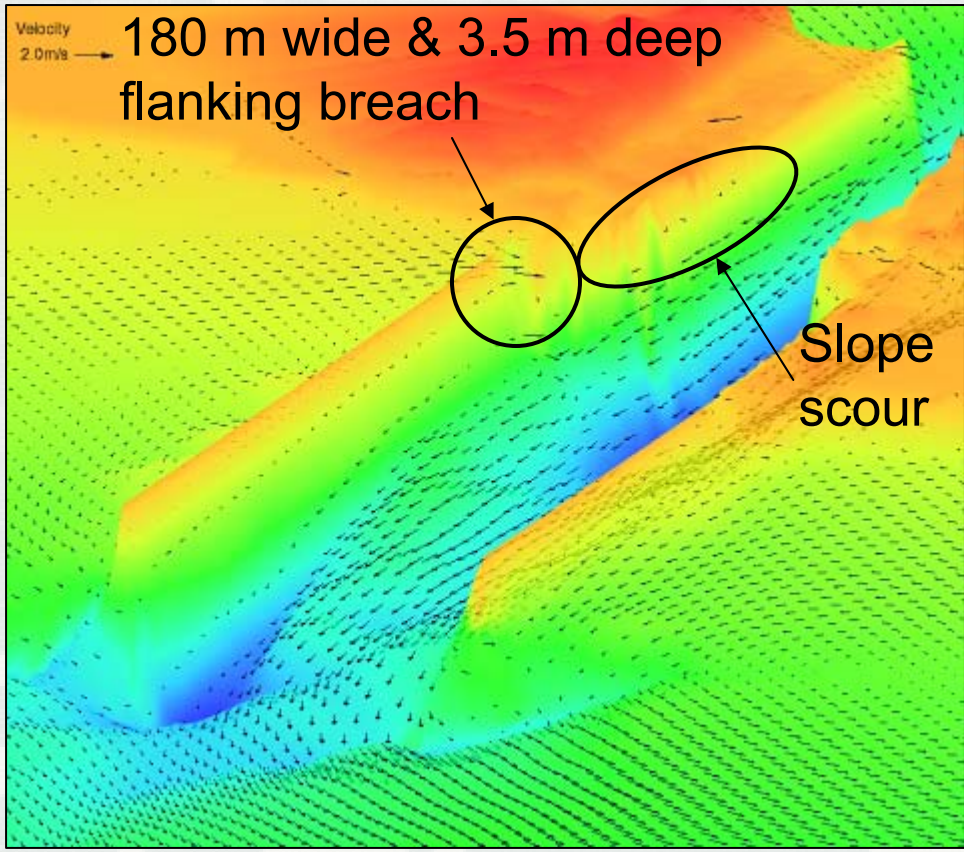
- Global sea level is expected to increase by 0.6 to 4.9 ft over the next 100 years.
- Many jetties are already approaching (or exceeding) 100 years of age (some jetties ~ 150 years old).
- Navigation project features – channels, jetties and breakwaters, dredged material placement sites, and infrastructure – may not function as intended.
- SLR will increase storm intensity inland.
- Proactive strategy is recommended
  - Assess present condition of navigation projects
  - Develop long-term plan for adaptive management: rehabilitation of structures, protocols for O&M, and navigation of coastal and estuarine waterways

Coastal Modeling System:
Matagorda Ship Channel, TX
Calculation of Flanking of Jetty

Storm surge over initial bathymetry

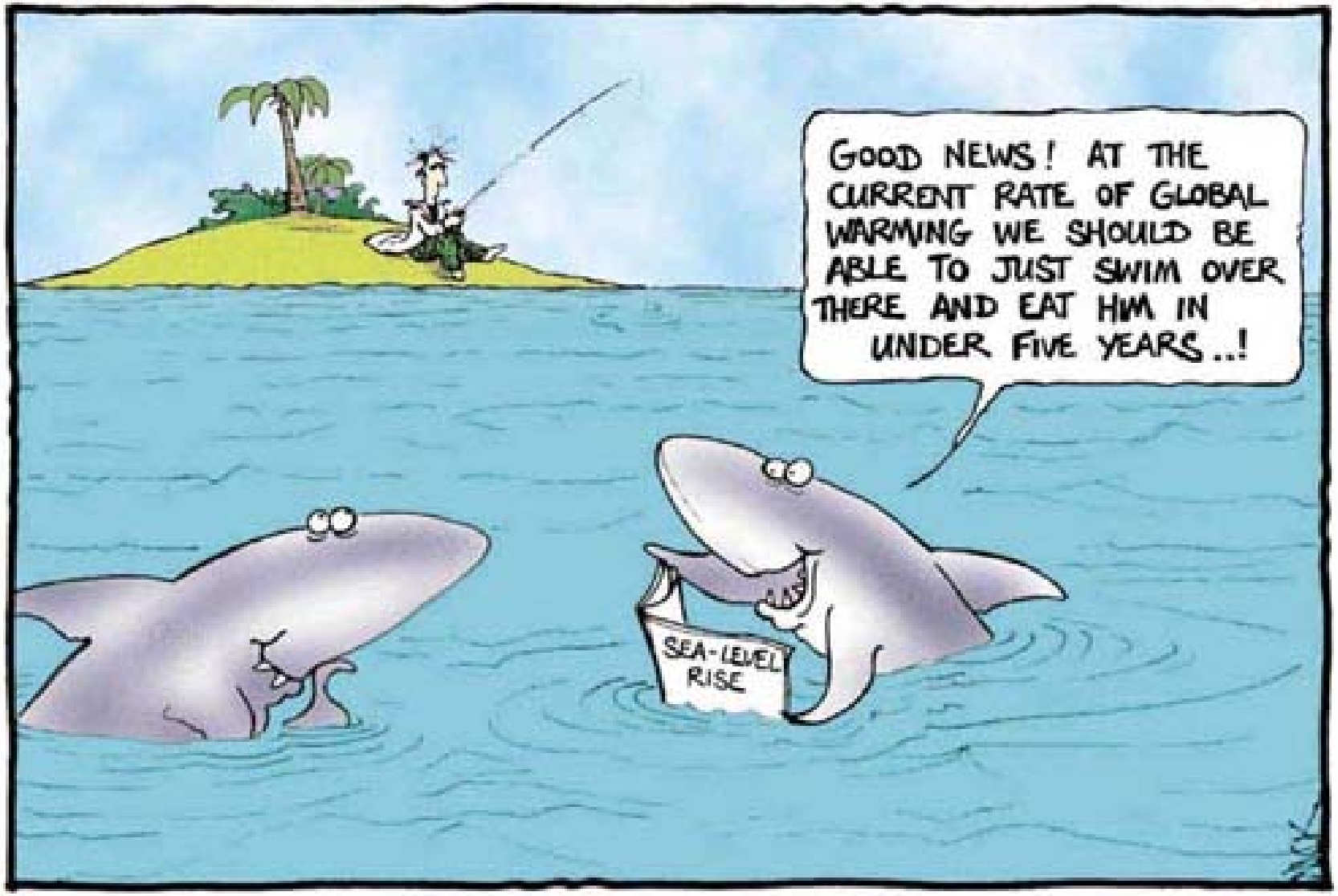


South jetty *flanking breach* + 12-hr



Simulation for a Category 3 hurricane

Thank you


GOOD NEWS! AT THE CURRENT RATE OF GLOBAL WARMING WE SHOULD BE ABLE TO JUST SWIM OVER THERE AND EAT HIM IN UNDER FIVE YEARS..!
SEA-LEVEL RISE