Use of Bioengineered Artificial Reefs for Ecological Restoration and Carbon Sequestration

Steven G. Hall, Daniel Dehon
Biological and Agricultural Engineering
Louisiana State University/LSU AgCenter
Baton Rouge, LA sgh1@cornell.edu

For Presentation at The American Scientific Affiliation Meeting Aug 2, 2009

Overview

- Coastal erosion and wetlands in Louisiana
- Coastal protection techniques
- “Oysterbreaks”
- Applications and Limitations
- Biblical Injunction to “shmar and abad” creation Genesis 2:15
- Dominion Gen 1:28,31

Current Status of Louisiana Coast

- Approximately 100 square kilometers of loss per year in 2003 (BARRAS et al. 1998)
- 90% of Wetland loss in the nation (USACE, 2004)/ 80/40
- Important ecosystem that provides a habitat for a wide variety of plants and animals
- Protect major metropolitan areas from hurricanes and other storms
- Serves as an important “self-renewing” economic resource

Projected Losses: -2050

http://www.pepyride.org/newsletter/images/smalllouisiana.jpg

Causes

- Sea level rise
- Land subsidence
- Altered hydrology from canal and levee construction
- Decreased riverine sediment input
- Salt water intrusion
- Increased erosion
- Hurricane impacts

Traditional Coastal Structures

- Revetments
- Seawalls and Bulkheads
- Groins and Jetties
- Breakwaters

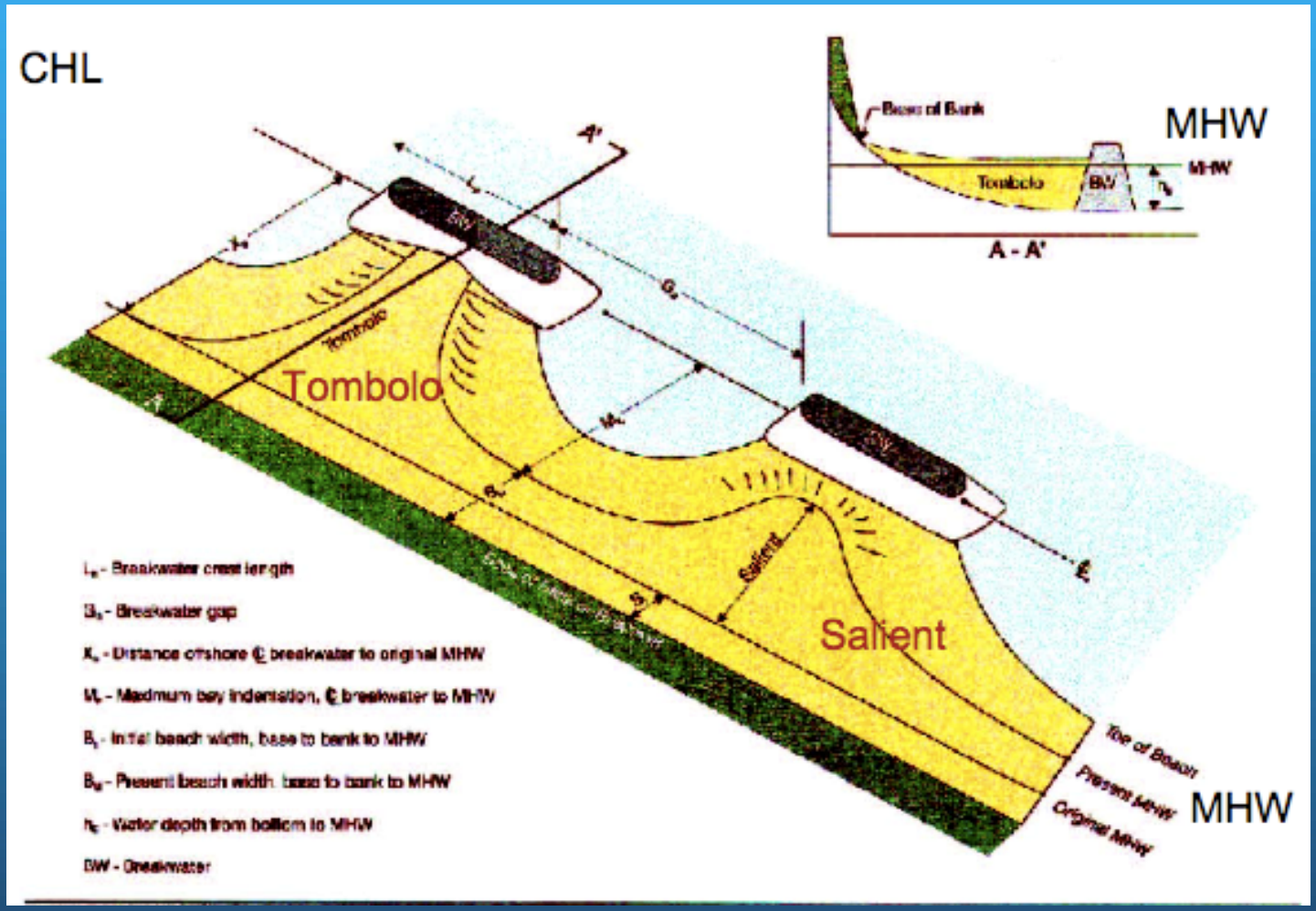
http://chl.erdc.usace.army.mil/

Breakwaters

- Breakwaters are structures constructed seaward and usually parallel to, the shoreline
- They attempt to break incoming waves before reaching the shore
- Series or standalone

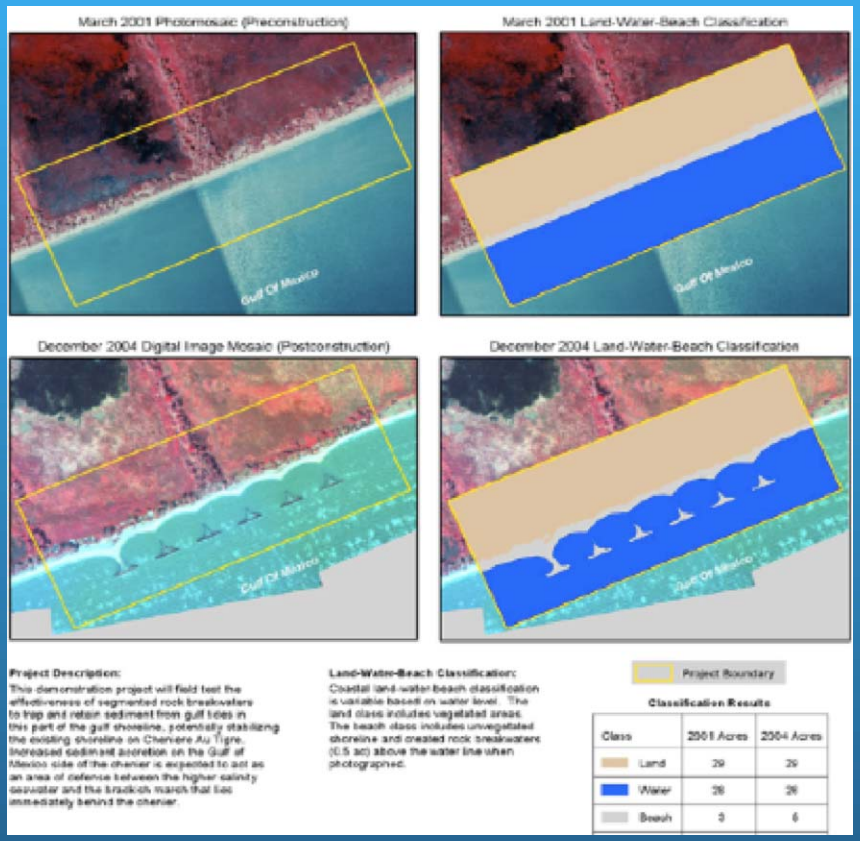
Hardaway and Gunn (1999)

Shoreline Response



Past Breakwater Project

- The Coastal Wetlands Planning, Protection and Restoration Act
- Cheniere Au Tigre project utilized breakwaters to grow land.



http://www.lacoast.gov/

Drawbacks of Current Techniques

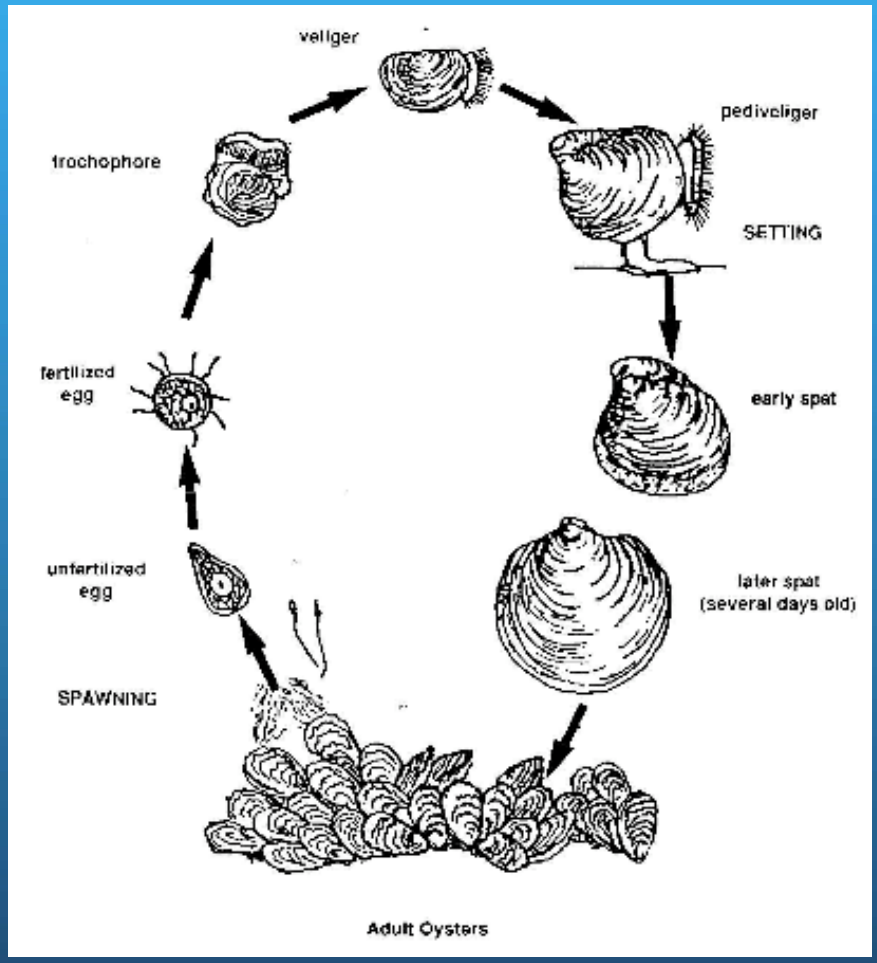
- Invasive methods that introduce new elements into an already fragile ecosystem
- Heavy equipment and mass of rocks being placed requires dredging
- High cost of materials, transport, and upkeep (energy…)

Biologically Enhanced Breakwaters

- Porous concrete structure with biological additives to promote growth
- Growth enhances overall stability, size, ecology,hydrology
- Target species: Eastern Oyster, *Crassostrea virginica*

Eastern Oyster

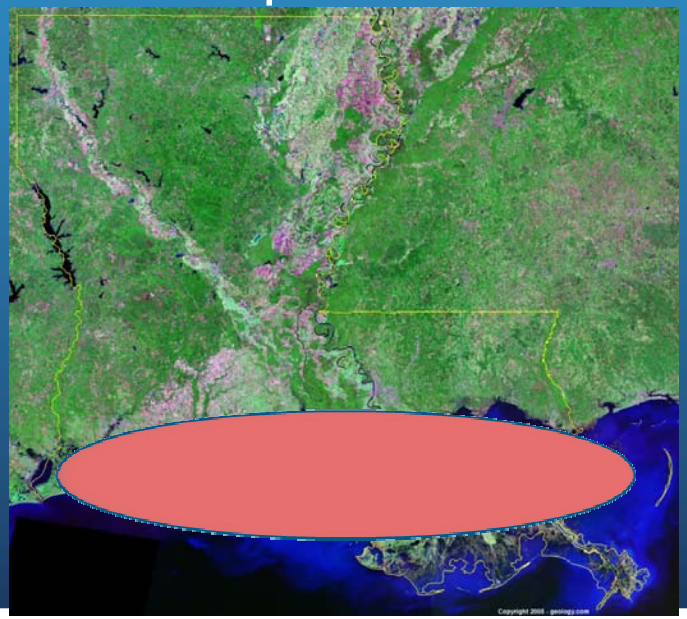
- Life Cycle: emplace structure near spawning events.
- Filter feeders are affected by water quality: salinity, DO, algae level, suspended solids, toxins, etc.
- Filter feeders also improve water quality as they remove particles from the water
- Salinity most important, +15ppt predation occurs, -5ppt increased stress



Berrigan et al. (1991)

Defining an “Oyster Zone”

- Current research is being done in order to define an “oyster zone” based on salinity data.
- This zone shifts throughout the year as the salinity levels are reduced by the input of fresh water during the wet season, changes with impacts of diversions…



Past Projects

- Campbell: as a structure increases in size its ability to dissipate wave energy also increases.
- Ortego: concrete with biological additive will experience greater growth than those without; quantified rates

Reef Design

- Interlocking rings
- Constructed to promote oyster growth
- Light weight
- Ability to scale up
- Different additives: Coloring, biological material, hardening agents

Placement Techniques

- Current research is being conducted to optimize the emplacement of these structures
- The ability to scale up these techniques is also important
- Different methods have been used and some have yet to be tested to move and place the rings on land and water
- Orientation of the pegs on the rings is key in proper stacking and alignment of the breakwater

Ecological Impact

- Oyster reefs provide juvenile fish refuge from predation.
- Also as shoreline progradation occurs, it will be important to utilize local plants – e.g. spartina grass and mangroves (*Avicennia germinans*), to ensure that these gains are lasting.

Carbon Sequestration

- As the amount of greenhouse gases increase, many are seeking ways of offsetting these increases
- Carbon sequestration is based on the capture and storage of this carbon
- Oyster shells are composed of calcium carbonate, $CaCO_3$ with a 12% carbon content
- 40 (Ca) + 12 (C) + 48 (3 O) = 100 molecular mass

Carbon Sequestration

- Initial measurements: carbon sequestration significant
- Rates measured, variable based on food, salinity, temp…
- Possible sequestration of all carbon from Louisiana in LA Oyster reefs (approx 50 miles)
- Current projects (CWPPRA, CIAP) <2 miles
- Proposed projects ~10 miles

Current Goals

- Map an “Oyster Zone” based on salinity data
- Document Construction and Emplacement
- Evaluate Growth
- Evaluate Wave Energy Reduction
- Ecological Benefits
- Use Data to Determine the Carbon Sequestration Ability

Pros and Cons

- Pro: biological, porous, low cost/material (85% less), ecological benefits, reduced wave energy (better dissipation), sustainable, carbon sequestration
- Con: oysterzone (or clam zone…), porous, higher mold costs, initial material import, requires (and takes) area
- Challenges: Public opinion (many evangelicals still not aware or supportive of responses to coastal changes); ocean acidification due to CO2 increases (0.3-0.5pH units predicted); coastal location changes; freshwater diversions,sediment, salinity changes
- Summary: A variety of techniques and the cooperation of many groups, political and scientific, are needed to create a solution to a problem that is largely human induced.

Summary

- Summary: A variety of techniques and the cooperation of many groups including religious, political, and scientific, are needed to create a solution to a problem that is largely human induced.
- Biologically based techniques hold promise as longer term, growing, lower cost (long term) and more sustainable solutions
- Challenges remain as we seek to protect and serve (Gen 2:15) coastal communities and ecosystems, but this biblical imperative is a calling in our time

Questions?

- shall5@lsu.edu
- www.bae.lsu.edu
- www.oratechnologies.com
- www.creationcare.org