Conventional and alternative shoreline control techniques and associated environmental impacts: annotated bibliography

Compiled and Written by Bran Wagner
School of Renewable Natural Resources, Louisiana State University AgCenter, Baton Rouge, LA 70803

For Evaluating Coastal Erosion Response Alternatives Workgroup

Meg Goecker, NOAA
Megan La Peyre, USGS LA FWCRU, LSU AgCenter
Chris Boyd, Mississippi State University
Melody Ray-Culp, FWS
Bryan Piazza, TNC
James Brennan, University of Washington

Goal: To collect scientific and grey literature pertinent to a review on conventional and alternative shoreline erosion control techniques and associated environmental impacts

First Tier Annotated Bibliography

Key words searched: Coastal/ Beach/ Shoreline Erosion, Breakwater, Ripraft, Dykes, Beach/ Bank/ Shoreline Armoring, Artificial Reef, Subsidence, Living Shoreline, Shoreline Stabilization, and Coastal Restoration.
Main Search Engines: Web of Knowledge, Google, and Google Scholar.

General Background

Beck, Michael W., et al. "Oyster Reefs at Risk and Recommendations for Conservation, Restoration, and Management." ***BioScience*** **61.2 (2011): 107-116. Print.**

This study evaluated 144 bays in 40 eco-regions to assess native oyster populations. The evidence suggests that native populations are less that 10% of the prior abundance when compared to 20- 130 years of historical catch data. Globally, the functioning of oyster reefs is in most cases extinct or in poor condition. The authors cite many reasons for the decline of natural oyster reefs world-wide and states that in most cases there multiple stressors that have contributed to the overall decline. The authors impress on the reader that the main factor that must be addressed is realization by managers and stakeholders that there is a problem.

Bertness, Mark, Brain Reed Silliman, and Robert Jefferies. "Salt Marshes Under Siege." ***American Scientist*** **vol. 92. (2004): 54-61. Print.**

This article from the American Scientist written by Bertness, Silliman, and Jefferies from Brown University discusses the unintentional anthropogenic causes for the degradation of salt-water marsh. The causes cited are higher nitrogen found in historic low nitrogen soils that allows for phragmites to intrude and is able to out-compete other species such as *Juncus* and *S. patens*. Another cause is a larger population of lesser snow geese due to increased farmland dedicated to grain production. Global warming is touched upon. And lastly the relationship between the marsh snail *Littoraria irrorata* and the overharvest of its natural predatory the blue crab. The research is focused in New England and gives insight to the other facets that threaten the coastal marshes of the United States.

Boesch, Donald F. "Scientific requirements for ecosystem-based management in the restoration of Chesapeake Bay and Coastal Louisiana." ***Ecological Engineering*** **26 (2006): 6-26. Print.**

Boesch's publication is one that calls attention to the need for resource management plans and scientific solutions to based in adaptive management. Ecosystem-based management as described by the author seeks to focus science to provide solutions for ecosystem restoration, bridge the gap between science and management, using more resources to understand the ecosystem, improve scientists' ability to communicate issues and concerns, and lastly, to integrate modeling, observation and research to promote adaptive management plans.

Borsje, Bas W., Bregje K. van Wesenbeeck, Frank Dekker, Peter Paalvast, Tjeerd J. Bouma, Marieke M. van Katwijk, and Mindert B. de Vries. "How ecological

engineering can serve in coastal protection." ***Ecological Engineering*****. 37. (2011): 113-122. Print.**

This paper written by Borsje et al. draws a distinction between the practice of civil-engineering for coastal protection and using facets of environmental engineering to better improve the outcome of projects seeking to reduce shoreline erosion. The argument against civil- engineering is that the unintentional consequences at times outweigh to ecological benefit of the construction. The authors put forth that there are more ecologically sound ways to produce the desired result that will both enhance the habitat and protect the shoreline from devastating wave action resulting in land loss and further erosion of coastal marshes.

Brumbaugh, Robert D., and Caitlyn Toropova. "Economic valuation of ecosystem services: A new impetus for shell- fish restoration?" ***IMCAFS*** **2.2 (2008): 8-15. Print.**

The authors of this paper want to draw a correlation between oyster reefs and the ecological service the reef provides beyond harvest. They urge more research in order to fully understand these benefits so that a proper value of not harvesting reefs can be assessed. The authors liken the oyster reef to other ecological engineers such as the coral reefs and mangroves that currently enjoy protection. They also advocate a need for change in public policy to encourage oyster restoration for purposes beyond harvest.

Coen, Loren D., et al. "Ecosystem services related to oyster restoration." ***MARINE ECOLOGY PROGRESS SERIES*** **341 (2007): 303-307. Print.**

The authors of this article wish to clarify the benefits of restoring oyster reef and make known that is not a simple quick fix to solve water quality deficiencies. The paper outlines ecological benefits natural and restored oyster reefs produce. But warn that introduction of non-native species can be detrimental and at times services such as reduced turbidity can be hard to quantify over large areas. Although, positive localized influence of oyster reef on quality of water has been verified. The authors urge further research to understand how bivalves as filter feeders provide services other than top-down control over excessive phytoplankton blooms.

Komar, Paul D. "Shore Leave." ***The Sciences*****. January/February 2000: 20-24. Print.**

This is an essay submitted to *The Sciences* by Paul D. Komar who is an oceanographer at Oregon State University, Corvallis. Komar discusses the idea put forth by Douglas L.Inman of sediment budgets by using the phrase “budget of beach sediments” where there are net losses and gains of sand in a natural beach system. Komar brings to light that many beaches are sand starved and points to disturbances in the natural replenishment caused by anthropogenic interferences along with slight changes in climate as the main culprits. Many of the building projects aimed at stopping erosion at one beach has denied sand from freeing moving and replenishing a beach further down the coast thus not solving the problem only transferring it to another location. Beach replenishment projects are costly but have become necessary and in the end it is only a temporary solution. Finally, Komar asks the reader to consider the role we contribute to the problem and then reevaluate solutions solve the issue of beach starvation.

Government State and Federal

BEM Systems Inc., and Coastal Planning & Engineering, Inc. "Report for Geoscientific Data Management for the Louisiana Sand/Sediment Resources Database (LASARD)." ***Coastal Protection and Restoration Authority of Louisiana*** **(2012): 131. Print.**
The Coastal Protection and Restoration Authority (CPRA) to consolidate geoscientific and related data pertaining to ecosystem restoration on a GIS platform developed LASARD (Louisiana Sand/Sediment Resource Database). The objective of LASARD is to organize data and findings from various sources into one database while minimizing cost and time lost to extensive searches by streamlining access to existing data sources.

CPRA-LA. "Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast." ***Coastal Protection and Restoration Authority of Louisiana*** **(2007): 82. Print.**
This is appendix I that outlines two alternative plans to address protection and restoration issues that face Louisiana coast for long term success and seeks to define the trade-offs necessary to carry out such a plan when chosen. Two rationales were used to select measures. The first is to provide maximum structural protection and landscape features will be created and kept up by mechanical means. This is without consideration of long-term cost of operation and maintenance at this stage of plan formulation. The second rational is based on varying levels of structural protection with non-structural alternatives. The measures reflect the cost/benefit constraint which the previous rational did not and the long-term O&M cost will minimized. This appendix is a summation of appraised measures as alternatives one and two in regards to a Master Plan.

DEP FL. "SHORELINE STABILIZATION and the Department of Environmental Protection." ***Department of Environmental Protection Florida*** **(n.d.): 4. Print**.
This is an outline from the state of Florida's Department of Environmental Protection on policy and permits needed to build seawalls and other shoreline stability structures.

GCERTF. "Gulf of Mexico Regional Ecosystem Restoration Strategy (Preliminary)." ***Gulf Coast Ecosystem Restoration Task Force*** **(2011): 112. Print.**
This is a preliminary document to outline the objectives and goals that might be pursued to restore the ecosystem in the Gulf of Mexico. The major actions outlined by the Gulf Coast Ecosystem Restoration Task Force are as follows: restore and conserve habitat; restore water quality; replenish and protect living coastal and marine resources; enhance community resilience. The Task Force's purpose is to coordinate all stakeholders and improve efficiency and effectiveness in the implementation of the Gulf Coast ecosystem restoration actions.

Good, Bill. "Vegetative Marsh Management in Louisiana Long-Range Recommendations." ***Coastal Vegetation and Wetland Restoration Program*** **(n.d.): 13. Print.**

This paper advocates two basic strategies to prevent the conversion of marsh to open water from erosion the first is to stabilize the soil and the next is succession acceleration. The author advocates planting vegetation as a less costly alternative to halt saltwater intrusion and the loss of land. Good goes on to describe the best methods and species specific planting for best results. The concept of succession acceleration is using plants that are adapted to the conditions at hand such as smooth cordgrass (*Spartina alterniflora*) in brackish marsh while cutgrass (*Zizaniopsis miliaceae*) are tolerant of fairly deep fresh water. The author suggests both of the species have the potential to recolonize quickly and will stabilize the soil. The paper also discusses seeding and the use of wave-dampening fences and enclosures to protect the plantings from grazers and wave energy.

Henderson, Jim, and Jean O'Neil. "Economic Values Associated with Construction of Oyster Reefs by the Corps of Engineers." ***ERDC USACE*** **(2003): 10. Print.**
This is a "technical note" that describes addition benefits that come from oyster restoration projects. The benefits are commercial and recreational as well as bottom stabilization and erosion protection associated with restored oyster reef and this paper reviews these topics a puts each into monetary terms. The prices attached are more than likely no longer relevant in the Chesapeake Bay but the author's argument is still sound.

Langlois, Summer R., and Stephanie M. Zumo. "ECOLOGICAL REVIEW." ***Biloxi Marsh Shoreline Protection 2007 State Surplus Project No. PO-72*** **(2011): 10. Print.**
This an Ecological Review to evaluate the likelihood of success for the Biloxi Shoreline Protection project. The project was approved to the construction phase of the process pending a design review.

LA-08. "LA-08 Bio-Engineered Oyster Reef Demonstration Project- Completion Report." ***Coast & Harbor Engineering*** **(2012): 144. Print**

LA-08 McGinnis, Thomas E., and Darrell J. Pontiff. "2012 Operations, Maintenance, and Monitoring Plan for Bioengineered Oyster Reef Demonstration Project (LA- 08)." ***Coastal Protection and Restoration Authority of Louisiana*** **(2012): 8. Print.**
The Bioengineered Oyster Reef Demonstration Project LA-08 consists of two, 215-foot segments of artificial reef. It is a breakwater project using OysterBreak Armoring Units with the objective to reduce shoreline erosion at Rockefeller Wildlife Refuge in Cameron Parish, Louisiana. The goals of the project are first to reduce erosion along the Gulf of Mexico shoreline and second to provide habitat for oysters which would create a self-sustaining reef, attenuate wave energy, retain sediment, and provide shoreline nourishment in the form of shell hash. The project began in February of 2012 and it is expected to have a five-year economic life. The first monitoring reports for this project are expected at the end of 2013 with a close out report finalized in 2016.

Louisiana Department of Natural Resources: Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and

Restoration Authority. *Coast 2050: Toward a Sustainable Coastal Louisiana.* Baton Rouge, La: 1998. Print.

This is a Louisiana State publication of an adaptive management plan for mitigating the economic and ecological cost of coastal degradation.

PO-22 Carter, Brady. "Monitoring Plan for Bayou Chevee Shoreline Protection." *LDNR/ Coastal Restoration and Management* (2003): 9. Print.

PO-22 Gossman, B.P, and B. Richard. "2011 Operations, Maintenance, and Monitoring Report for Bayou Chevee Shoreline Protection (PO-22)." *Coastal Protection and Restoration Authority of Louisiana, Office of Coastal Protection and Restoration, New Orleans, Louisiana* (2011): 19pp. and Appendices.
The Bayou Chevee Shoreline Protection Project PO-22 was completed in 2001. The purpose of this construction was to provide shoreline protection against the high wave energies found in Lake Pontchartrain and Chef Menteur Pass that has caused extensive shoreline erosion. The construction utilized 8,875 linear feet of rock bankline protection along the shoreline of the North Cove and South Cove areas. It was hypnotized that the newly enclosed areas should provide greater abundance of submerged aquatic vegetation (SAV) to colonize. The project has been deemed successful in that the shoreline erosion has been lessened by the construction but cites there were losses between 2005 and 2008 as the effects of Hurricane Katrina overcame the rock structure. The SAV growth has both maintained and increased abundance in comparison to the reference sites in the North Cove and South Cove. Due to settling a lift of the construction is recommended as of 2011 Monitoring Report because there are portions of the rock dyke that are no longer providing adequate protection.

Shipman, H., Gelfenbaum, G., Fresh, K.L., and Dinicola, R.S., eds., 2010, Puget Sound Shorelines and the Impacts of Armoring—Proceedings of a State of the Science Workshop." *U.S. Geological Survey Scientific Investigations Report 2010-5254* (2009): 91-102. Print.
This is a collection of fifteen research papers compiled for a workshop pertaining to Puget Sound. The collection includes papers on human dimensions, geological oceanographic processes, ecological responses, and management needs. The conference brought together numerous local, state, and national representatives to discuss impacts of bank armoring and shoreline erosion alternatives. The main objective as outlined on page 221 as follows: (1) to summarize the 'state of the science' on the physical changes and ecological impacts of shoreline armoring, (2) to assess the levels of certainty of this knowledge, and (3) to identify information and data needs that will advance the understanding of the impacts of armoring on Puget Sound beaches.

TE-40 Brass, Agaha, and Bethany Krumrine. "Ecological Review." *LDNR Restoration Technology Section Coastal Restoration Division* (2003): 17. Print.

TE-40 Williams, Chris, Patty Taylor, Daniel Dearmond, and GSE Associates, Inc. "Project Completion Report Installation of Sand Fence on Timbalier Island (TE-40)." *LDNR* (2006): 5. Print.

TE-40 Rodrigue, L B., G. P. Curole, and D. M. Lee. 2011. 2011 Operations, Maintenance, and Monitoring Report for Timbalier Island Dune/Marsh Restoration Project (TE-40), Coastal Protection and Restoration Authority of Louisiana, Office of Coastal Protection and Restoration, Thibodaux, Louisiana. 27 pp. and Appendices.

"The Timbalier Island Dune/Marsh Restoration (TE-40) project is a 20-year project designed to restore the eastern end of Timbalier Island through dedicated dredging of local sediment sources, and stabilization of the newly deposited sediment through sand fencing and vegetative plantings in Terrebonne Parish, Louisiana." The project's objectives include restoration of the eastern end of Timbalier Island and to maintain the lateral migration through dune construction and elevation, vegetation plantings (including smooth cordgrass, salt meadow cordgrass, bitter panicum and sea oats) and the project incorporates sand fencing to reduce the rate of loss of sand in the treated areas. The *2011 Monitoring Report* reveals that to date the project has met only one of its four goals, which was to maintain longshore transport of the Timbalier shoreline. One of the main oppositions to the project has be realized thus far has been the magnitude and frequency of recent tropical storms and it is for this reason at least one of the goals has not been met to date.

TE-41 Lear, E. and D. Dearmond 2004. 2004 Operations, Maintenance, and Monitoring Report for Mandalay Bank Protection Demonstration (TE-41), Louisiana Department of Natural Resources, Coastal Restoration Division, Thibodaux, Louisiana. 33pp.

TE-41 Lear, E., D. Dearmond, and T. Folse. 2007. *2007 Operations, Maintenance, and Monitoring Report for Mandalay Bank Protection Demonstration (TE-41) Project, Louisiana Department of Natural Resources, Office of Coastal Restoration and Management, Thibodaux, Louisiana.* 32 pp. plus appendices.

TE-41 Lear, Elaine, Brain Babin, Glen Curole, and Todd Folse. "2011 Closeout Report for Mandalay Bank Protection Demonstration (TE-41) Project." *State of Louisiana Coastal Protection and Restoration Authority Office of Coastal Protection and Restoration* (2011): 46. Print.

These are the monitoring and final reports on the Mandalay Bank Protection Demonstration TE-41. The project sought to compare two off-bank and two blowout treatments for cost effectiveness and performance. The sites were monitored for five years beginning in 2003 but were built to last twenty years. The project treatments included articulated concrete revetment mats, straight-walled fiberglass sheet pile, A-Jacks concrete interlocking blocks, and staggered treated lumber.

TE-45 Cowan, Jean L.W. "Ecological Review- Terrebonne Bay Shoreline Protection and Oyster Reef (DEMO) TE-45." *LDNR Restoration Technology Section Division* (2003): 19. Print.

TE-45 Folse, Todd. "Monitoring Plan for Terrebonne Bay Shore Protection Demonstration TE-45." ***LDNR/ Coastal Restoration and Management*** **(2005): 16. Print.**
TE-45 T. Baker Smith Inc. "Project Completion Report Terrebonne Bay Shoreline Demonstration Project TE-45." ***LDNR*** **(2008): 46. Print.**

TE-45 Melancon, Jr., E.J., M.A. Linson, G.P. Curole, D.A. Dearmond, and Q.C. Fontenot. "2010 Operations, Maintenance, and Monitoring Report for Terrebonne Bay Shore Protection Demonstration (TE-45)." ***Coastal Protection and Restoration Authority of Louisiana, Office of Coastal Protection and Restoration, Thibodaux, Louisiana*** **(2010): 51. Print.**

TE-45 Ledet, Adam. "2011 Annual Inspection Report for Terrebonne Bay Shoreline Protection Demonstration TE-45." ***CPRA-LA*** **(2011): 22. Print.**
This group of papers describes the TE-45 Terrebonne Bay Shoreline Protection Demonstration Project from the *Ecological Review* completed in 2003 through the 2011 *Annual Inspection Report.* Due to marsh loss the interior of the salt marsh has been more exposed to tidal and wave action, which in turn has lead to higher salinity further inland, that has caused further damage to fragile ecosystems. The purpose of this demonstration project was to implement and evaluate then document the effectiveness of three different techniques designed to reduce erosion and promote growth of oyster reefs. TE-45 was conducted on the northern marshes of Lake Barre and used three different shoreline protection treatments that included Triton Gabion Mats filled with rocks, A-Jacks Concrete Armor Units, and Reefblks Steel Rebar Triangular Units with Oyster Shell Bags. The 2011 inspection indicates the 8-year project has been successful in that all installations were intact and needed no rehabilitation and there was little evidence of salinity spikes that would have further damaged the vegetation behind the treatments.

U.S. EPA (2009). Synthesis of Adaptation Options for Coastal Areas.Washington, DC, U.S. Environmental Protection Agency, Climate Ready Estuaries Program. EPA 430-F-08-024, January 2009.
Synthesis of Adaptation Options for Coastal Areas is a discussion on adaptive management for coastal environments in the face of climate change. Outlined within are the impacts on coastal areas due to climate change and adaptive management options to mitigate the effects of climate change. Each option is summarized as climate stressor, additional management goals, benefits, constraints and also gives examples of where the adaptive management was utilized. The EPA has published an easy to follow overview on the issues and techniques, complete with useful websites for further information that managers may find helpful.

Whalen, Laura, et al. "Practitioner's Guide: Shellfish-Based Living Shorelines for Salt Marsh Erosion Control and Environmental Enhancement in the Mid-Atlantic." ***Partnership for the Delaware Estuary Inc.*** **(2011): 47. Print.**
This is a guide that outlines the most effective methods and considerations necessary to build a living shoreline to mitigate the effects of shoreline erosion. There are several living shoreline solutions suggested by the authors that take into account shoreline

characteristics, suitability, hydrology, and takes a look at cost and benefits both economically and environmentally. There is data on success rates of projects and gives an account of how the projects were implemented. Also the authors included helpful web links to answer further questions the reader might have

Thesis And Reviews

Currin, C. A., W. S. Chappel, and A. Deaton. "Developing alternative shoreline armoring strategies: The living shoreline approach in North Carolina, in Shipman, H., Dethier, M.N.,

This is a review of scientific data in regards to the ecological value of the implementation of living shorelines as an alternative to bulkheads and indiscriminate bank armoring. The main purpose of this paper is to persuade policy and regulatory bodies to reassess current trends to include living shorelines as a viable alternative to shoreline stabilization. The authors also acknowledge the need to educate the general public on the economic and ecological benefits of natural shorelines while discussing the drawbacks of bulkheads and bank armoring in order to execute a sustainable approach to shoreline protection.

Dehon, Daniel D. "INVESTIGATING THE USE OF BIOENGINEERED OYSTER REEFS AS A METHOD OF SHORELINE PROTECTION AND CARBON STORAGE." ***A Thesis: The Department of Biological and Agricultural Engineering*** **(2010): 57. Print.**

This is a thesis research paper written on bioengineered native oysters used as ecological engineers to improve water quality and to capture and store carbon while protecting coastal wetlands. The experiment used oysterbreaks, which are concrete rings that can be stacked and interlocked as a solid substrate for oyster growth. The main purpose of the project was to evaluate the carbon storage potential of the oysters on the structures. The author believes this method is both sustainable and cost effective in regards to shoreline protection with the added benefit of long-term carbon storage that inevitably improves water quality.

Gedan, Keryn B., Matthew L. Kirwan, Eric Wolanski, Edward B. Barbier, and Brian R. Silliman. "The present and future role of coastal wetland vegetation in protecting shorelines: answering recent challenges to the paradigm." ***Climatic Change*****. 106. (2010): 7-29. Print.**

This paper is a “literature review and meta-analysis of wave attenuation data” to test the theory that coastal wetlands “stabilize shorelines and protect costal communities.” The authors found that indeed wetlands are a key factor in shoreline protection but the amount of protection is limited by the size of storm surges that at times threaten the coast. They feel that a functioning wetland in concert with other natural and man-made wave breaks that mimic natural processes are essential to protect coastlines, mitigate damage to property and reduce the threat to human life. This paper was written to refute claims of contemporary papers that claimed in small scale experiments wetland plants did not protect shorelines during single storm events.

Ortego, Tyler. "ANALYSIS OF BIOENGINEERED CONCRETE FOR USE IN A SUBMERGED REEF TYPE BREAKWATER." ***A Thesis Submitted to the Graduate Faculty of the Louisiana State University*** **(2006): 55. Print.**

The research for this thesis was to find out if additions such as oyster shell or cottonseeds to concrete used as breakwater structures would increase oyster recruitment faster than concrete alone. It has been previously determined that oyster reefs are effective in the mitigation of erosion in a low wave energy environment. There were two objectives in this study. First, to determine whether adding cottonseed or oyster shell to concrete breakwater would grow more oysters giving it a larger cross section than concrete without biological additives and secondly, to measure to the strength and resistance to failure with increasing amounts of cottonseed. The data showed that both additions to the concrete seem to increase recruitment the author gives two possible reasons for this. Cottonseed has free fatty acids that may create highly attractive substrate and may enhance growth by an enriched diet. And the oyster shell mixed in the concrete could be mimicking some natural chemical cues therefore more oysters are willing to settle on the newly created substrate.

Ranasinghe, Roshanka, and Ian L. Turner. "Shoreline response to submerged structures: A review." ***Coastal Engineering*****. 53. (2006): 65-79. Print.**
This is a literature review on the impact of submerged breakwaters used to provide both beach protection and provide better surfing conditions that are aesthetically pleasing. These authors bring to light that these structures may be causing adjacent beach erosion but there is not enough research on the effects of submerged breakwaters to be confident. They site that while shoreline erosion response data is readily available shoreline erosion in the lee of breakwaters is inconsistently reported and therefore the effects are largely unknown. Through the review it was found that there were instances of both erosion and accreditation on shoreline but cite that there maybe a combination of factors that lend cause to these effects. This review, the authors hope, will be a precursor to further research investigating the relationship between submerged structure and the shoreline they are built to protect.

Restall, S.J., L.A. Jackson, Georg Heerten, and W.P. Hornsey. "Case studies showing the growth and development of geotextile sand containers: an Australian perspective." ***Geotextiles and Geomembranes*****. 20. (2002): 321-342. Print**
This is a review of the use of geotextiles in Australia over twenty years. The paper outlines projects, construction techniques, and materials used in protecting shorelines citing successes and the evolution of innovations over time.

Saathof, Fokke, Hocine Oumerac, and Simon Restall. "Australian and German experiences on the use of geotextile containers." ***Geotextiles and Geomembranes*****. 25 (2007): 251-263. Print.**
This is a rehash of an earlier paper written by Restall on Australian use of geotextile but includes German experiences and studies on their use of geotextile sand containers to combat erosion, provide scour protection and scour fill in, groynes, seawalls, breakwaters and dune reinforcement. This is coupled with investigations leading to hydraulic

modeling to create reliable formulas to assess the stability of the geotextile sand containers to are used as storm water protection and dune reinforcement.

Research and Data

Bozek, Catherine M., and David M. Burdick. "Impacts of seawalls on saltmarsh plant communities in the Great Bay Estuary, New Hampshire USA." ***Wetlands Ecology and Management.*** **13. (2005): 553-568. Print.**

The research by Bozek and Burdick look at the salt marsh vegetative diversity in found in Great Bay Estuary of New Hampshire and the impacts of the use of seawalls to protect shoreline erosion. They noted there was a loss of transitional diversity of vegetation that is found in naturally occurring systems and put forth the question are the seawalls necessary in all cases and there are other solutions. The concluding Idea in this publication is managed retreat where in some cases the removal of seawalls could allow for the natural retreat of the salt marsh as sea levels rise that would keep intact the diversity of plants that provide habitat for the species and bank stability.

Bricio, Laura, Vicente Negro, J. Javier Diez, and Jose S. Lopez. "Functional and Environmental Design of Detached, Low Crest Level Breakwaters." ***Journal of Coastal Research*****. 28.1a (2012): 131-142. Print.**

The authors of this research paper are seeking to standardize a formula where detached breakwaters can be built off coastlines and be successful in protecting beaches from damaging wave action. The research was conducted on existing detached breakwaters on the coast of Spain. The researchers first considered the site's "geomorphology and local marine climate" after the breakwaters were built to quantify the effectiveness of the construction. Then the authors propose five design steps that should be followed in order for a successful detached breakwater being deployed. The authors admit that the quantitative results of their research is limited due to the their chosen project but feel as if it is a starting point for continued scientific investigation on this subject.

Burke, David G. "Assessment of Hybrid Type Shore Erosion Control Projects in Maryland's Chesapeake Bay Phases I & II." ***Horn Point Environmental Laboratory University of Maryland Center for Environmental Science*** **(2005): 112. Print.**

This is an assessment of failures and successes found with a hybrid type of shoreline protection often called "Living Shorelines." The study found while marsh plantings worked well and mitigation coastal erosion in low wave energy harder structure is needed if wave action is excessive. The research also noted that the presence of SAVs (Submerged Aquatic Vegetation) was not visibly affected by the presence of hard structure such as groins and sills. Rather the presence of SAV in most likely connected to water quality.

Chang, Hsien-Kuo, Jin-Cheng Liou, and Wei-Wei Chen. "Protection Priority in the Coastal Environment Using a Hybrid AHP-TOPSIS Method on the Miaoli Coast, Taiwan." ***Journal of Coastal Research*****. 28.2 (2012): 369-374. Print.**

This article proposes a method of determining action of protecting valuable coastline from damaging winds and summer storms found in Taiwan on the Miaoli Coast in the face of a governmental budget deficit. The researchers use a method called the analytic hierarchy process (AHP) where criteria is determined hierarchically and given weights when compared then ranked in order flush out best possible solutions in concert with expert opinions. TOPSIS for short is the technique for order preference by similarity to ideal solution. It is a way to organize multi-attribute or multi-criteria decision-making process that can be used for real world problems. The authors seek to combine the two processes to solve the issues faced by an eroding coastline, tourism, and the need to have successful fishery.

Comoss, Denise A. Kelly, and Harry Z. Leslie. "Innovative erosion control involves the beneficial use of dredge material, indigenous vegetation and landscaping along the Lake Erie Shoreline." ***Ecological Engineering*****. 19. (2002): 203-210. Print.**
The project described in this publication is an answer to a problem found in the Great Lake region where erosion and excessive nutrients into the lakes from runoff is an issue. The project involved using uprooted trees in place of rocks to make timber groins and then filled the spaces with sand dredged locally. The project then used geotextile and wattles, which are a more cost effective way to control sediment and will help aid newly, planted indigenous plants placed to stabilize the shoreline. The goal of the project was to replace lost shoreline, slow down erosion, filter excessive nutrients, and in doing so keep the area as natural looking as possible. According to the authors the method was used was also an inexpensive alternative solution to traditional methods that have been used to solve the same issues.

Day, Jr., John W., and William J. Mitsch. "Management Approaches to the Ecological Restoration of the Mississippi Basin." ***Department of Oceanography and Coastal Sciences, School of the Coast and Environment*** **(2004): 16. Print.**
This paper focuses on the Mississippi-Ohio-Missouri river drainage and the high nitrogen inputs that are leading to poor water quality and contributing to the hypoxic zone in the Gulf of Mexico. High nitrate-nitrogen used in fertilizers for agriculture comprised mainly of corn crops in the Midwest are entering the basin untreated due to rain events and unchecked runoff from fields. The authors cite three main causes for the ecological damage in the Mississippi Basin: wetland/ habitat loss; major drainage networks and hydrologic disruption; and excessive fertilizer use. The paper also suggest that in order to see a reduction of the hypoxic effect in the Gulf of Mexico there would need to be 2.5 million ha of wetlands restored.

Dobberstine, Jim. "Living Shorelines: Alternative shoreline protection." ***Houston-Galveston Area Council*** **(2007): 1-6. Print.**
This is an overview of three projects that used offshore wavebreaks consisting of shell and/or riprap rather than shoreline bulkheads or other hard structures. Pictures document success in creating habitat, producing an artificial reef, and improving water quality.

Gallego-Fernández, Juan B., Ivan A. Sánchez, and Carlos Ley. "Restoration of isolated and small coastal sand dunes on the rocky coast of northern Spain." *Ecological Engineering*. 37. (2011): 1822-1832. Print

The Basque Country features steep coastlines and a sand dune system that has experienced pressure, degradation, and fragmentation from people visiting the coastline on vacation or from building towns and cities on the dunes or nearby. These researchers are interested in the natural progression of vegetation on restored sand dunes. There are many plant species in the region that are threated or endangered. This is partly to do with natural disturbances and anthropic interference in the ecosystem. The site was studied for seven years and looked at passive recovery of plants on a restored dune. The researches noted that there was establishment of rare and threaten species then made comparisons to near by reference dunes for composition and abundance. The authors suggest when restoring a dune system that the site chosen should be close to existing dunes and to restore as many as possible to limit fragmentation and expedite seed propagation to abate the extirpation of species diversity in the region due to climatic and mad made disruptions to the natural dune systems.

Giordano, Anthony, and John Rowland. "Use of Federal Sand for Beach Nourishment and Shore Protection Projects." *Marine Georesources and Neotechnology* 17 (1999): 91-97. Print.

This is a paper that focuses on accessing sand deposits from federal waters on the outer continual shelf to replenish eroded state beaches on the Atlantic and Gulf of Mexico. This is a publication from The US Department of Interior's Mineral Management Service (MMS) that has sought to provide policy and guidance for mineral resources located on the federal portion of the continual shelf. The MMS and eight coastal states have joined a cooperative agreement to investigate offshore sand deposits while evaluating geological and environmental information associated with these deposits for the use in restoration projects along the coast.

Good, Bill. "Vegetative Erosion Control In High Wave-Energy Environments: 1987 Field Trials Using Mats And Fences." *Coastal Vegetation and Wetland Restoration Program* (1988): 24. Print.

This paper outlines a study conducted by the author to test the effectiveness of a relatively low-cost vegetative erosion control system determined by varying intensities of wave-energies. The project planted smooth cordgrass (*Spartina alterniflora*) through fiber mats and constructed a fence seaward to protect the new plantings from direct wave action in four different locations that varied in fetch that relates to wave-energy. The author determined the project was largely successful but cannot account for all variables because the initial fencing failed and had to be redesigned mid-study.

Hoagland, Porter, Di Jin, and Hauke L. Kite-Powell. "The Costs of Beach Replenishment along the U.S. Atlantic Coast." *Journal of Coastal Research*. 28.1a (2012): 199-204. Print.

Hoagland et al. produced a statistical model to determine cost effectiveness of beach replenishment so that coastal managers can make informed decisions on the best course of action when repairing coastal regions. The model looks at volume of material needed,

time of year, length in feet of a beach to be replenished, and primary funding source are among the variables to calculate total cost of a given project.

Hornsey, W.P., J.T. Carley, I.R. Coghlan, and R.J. Cox. "Geotextile sand container shoreline protection systems: Design and application." ***Geotextiles and Geomembranes*****. 29. (2011): 425-439. Print.**
Geotextile Sand Container or GSC's is the subject of this research project. The authors tout that the GSC has been rethought and some of previous drawbacks have been eliminated or improved upon. Use of GSC is an alternative method to protect coastline where rock and rubble are too costly or unavailable. Test were performed in Australia and these consist of best final shape, amount of fill, material that is resistance to punctures and other damage, a new easy to use wet/dry patch to repair tears, limit on UV exposer, and abrasion resistance. The researchers found that smaller containers work more effectively and are less prone to complete failure, as there are more on site than the previous longer tubes deployed to protect coastal regions. There are also recommendations on the size of the grain of sand and a table showing retention rates of particulate size. This paper suggest that if recommendations are considered then the placement of geotextile sand containers can be a successful venture for the ongoing protection of coastlines and beaches.

Jadhav, Ranjit, Qin Chen, and Weiming Wu. "Wave Climate in a Shallow Estuary of a Rapidly Eroding Coast." ***Department of Civil Environmental Engineering, Louisiana State University*** **(n.d.): 21. Print.**
This is a study over a period of seven months in which the researches looked at direction wave data to determine the characteristic of the wave environment in Terrebonne Bay, Louisiana. The study site is a shallow bay that has experienced high levels of land loss that threatens commercial and recreational as well as the community's well being. The purpose of the study was to collect wind-sea and swell data to better understand the environment and to help facilitate protection strategies for the wetlands that are vanishing.

Jones, Kim, and Emile Hanna. "Design and implementation of an ecological engineering approach to coastal restoration at Loyola Beach, Kleberg County, Texas." ***Ecological Engineering*****. 22. (2004): 249-261. Print**
Loyola Beach in Texas was the site chosen to implement an alternative method of coastal restoration to attain goals of lower soil moisture in restored areas and to preserve the natural beach ecosystem with ascetics and cost at the forefront of the project. Another objective was to determine a technique to "evaluate ecological coastal erosion designs using geotechnical data and other parameters." The researcher looked at grain size and used a plasticity index to classify the site on which the project was to be built. Data was acquired on moisture content of the soil and modeled an erosion mitigation to make comparisons for ecological coastal design, which takes into account "incipient sediment motion of cohesion-less soils, in a low wave energy environment." After considerations were taken into account and the best course of action determined the project moved forward. The project used a number of different materials in concert to attain results that were satisfactory. The authors assert in this publication that the methods and materials

used cost only one-third of the amount that would have been normally been spent using conventional erosion control methods.

Jones, Kim, Xubin Pan, Abel Garza, and John Lloyd-Reilley. "Multi-level assessment of ecological coastal restoration in South Texas." ***Ecological Engineering*****. 36. (2010): 435-440. Print.**

This paper is an evaluation on the Loyola Beach, Kleberg County Texas project implemented in 2003. There were some issues but overall the researchers deemed it successful in that it slowed erosion and generally thought that it was more of a benefit ecologically than traditional hard structures would have been. Aerial and on site photography was used to make comparisons and the experimental methods for determining soil composition and strength were repeated from the original study. Also data on soil moisture was taken and analyzed as it was in the first study. The researchers included an assessment on vegetation for amount of species, cover, and diversity. The study determined there was two main issues with the original project first that more structure was needed for the toe and second period maintenance is required for upkeep. This evaluation comes five years after the project was completed and in that time the researchers found no visible evidence of erosion or retreat on the project site.

LANDRY, CRAIG E. "Coastal Erosion as a Natural Resource Management Problem: An Economic Perspective." ***Coastal Management*****. 39. (2011): 259–281. Print.**

Landry proposes and alternative to the two different traditional economic models used to consider the cost of beach replenishment projects. He discusses the use of dynamic optimization models that are specifically tailored to natural resource management use the economic benefit of services provided and take into account the cost of natural processes such as sea-level rise, storm surges, and erosion. Landry admits that there is a drawback to the dynamic optimization model; it is mathematically complex and does not render itself to a rule-of-thumb. He suggest that there should be more research with the end goal that policy makers and managers in state and local government could utilize this model as a tool in their analysis of future projects.

Lee, E.C., and R.S. Douglas. "Geotextile tubes as submerged dykes for shoreline management in Malaysia." ***Geotextiles and Geomembranes*****. 30. (2011): 8-15. Print.**

This paper looks at using geotextiles as a way to subvert the effects of erosion to coastlines by creating a dyke submerged at a depth of 1-meter freeboard at low tide and a distance of 150 meters from the existing shoreline. As a result there was an accumulation of deposited sand foreshore and provided a gentle gradient with shallow water that diminished wave action reducing potential for further erosion.

Lee, F.C, John R.C Hsu, and W.H Lin. "Appraisal of storm beach buffer width for cyclonic waves." ***Coastal Engineering*** **58 (2011): 1049-1061. Print.**

This paper analyzes the effects of sporadic storm surges on berms and dunes and the sand loss as a result of high-energy wave action. Test were preformed in a large wave tank and numerically assessed using the SBEACH model for three wave conditions in terms of

storm return period, median sand grain size, berm width, and water levels. The "SBEACH (Storm-induced BEAch CHange) is the most well-known tool for assessing beach profile changes according to the authors. The study utilized only monochromatic wave action in the SBEACH model which the author admit the results of the test maybe less than realistic. And therefore advocate using a random wave condition to obtain results that may be closer to real world events.

Liou, Jin-Cheng, Hsien-Kuo Chang, Wei-Wei Chen, and Shyne-Ruey Liaw. "Beach Erosion and Preventive Countermeasure at Kangnan Coast, Taiwan." ***Journal of Coastal Research*****. 25.2 (2009): 405-416. Print.**

This publication was an evaluation of extended breakwater and groins built to protect a harbor and the erosion that was caused to adjacent beaches. The study used satellite imagery to detect retreat of beaches and bathometric planform variation to quantify the area were sand was eroded or deposited. The researcher suggest underwater breakwaters be used to mitigate further erosion issues.

Mani, J.S. "Beach Accretion and Erosion with S-Type Rubble Mound Sea Wall." ***Journal of Coastal Research*****. 23.4 (2007): 921_929. Print.**

This research was carried out on the Chennai coast on the east coast of India. They looked at the effectiveness of an S-type seawall built to protect against erosion that was threatening a chemical company and create a landing beach for fishermen. The project had six objectives which included preventing a bay from forming, reduce time waves were in contact with the structure, low cost, create beach, prevent direct wave action on shoreline, and maintain seabed morphology. According to the author the project was successful in accruing sand and forming a spiral beach in front of the seawall and no change to the seabed morphology was caused by the installation.

Montague, Clay L. "Recovering the Sand Deficit from a Century of Dredging and Jetties along Florida's Atlantic Coast: A Reevaluation of Beach Nourishment as an Essential Tool for Ecological Conservation." ***Journal of Coastal Research*****. 24.4 (2008): 899-916. Print.**

This publication asserts that Florida has a sand deficit from dredging channels and then moving the material away from the sand replenishment system upland and offshore. The jetties that were built to protect these channels from filling in have disrupted the southward movement of sand that would normally replenish the beaches. Rising sea levels and loss of beaches, which is also crucial habitat, threaten not only the nearby property but also the sea turtles that rely on sandy substrate to build nest. Good quality sand is in short supply but alternatives are being considered.

Morley, Sarah A., Jason D. Toft, and Karrie M. Hanson. "Ecological Effects of Shoreline Armoring on Intertidal Habitats of a Puget Sound Urban Estuary." ***Estuaries and Coast*** **35 (2012): 774-784. Print.**

The subject of this paper is the effect of shoreline armoring on the estuarine community. The study took place along Duwamish River estuary (Washington State, USA), which is estimated to be 66% armored along the shoreline. The researchers "evaluated differences in temperature, invertebrates, and juvenile salmon diet between armored and unarmored intertidal habitats." They found there was a rather large difference in the amount of

species richness on the unarmored sites opposed to the armored. The researcher attribute the findings to shoreline hardening that limit inevitably reduces availability of habitat for burrowing benthic species and steeper banks are not advantageous for submerged aquatic vegetation that can be both a source of food and protection for taxa. The authors admit it would not necessarily be cost-effective to return already urban landscapes back their natural state but urge to limit or at least improve the design of future shoreline development projects.

Morton, Robert A., Tara Miller, and Laura Moore. "Historical Shoreline Changes Along the US Gulf of Mexico: A Summary of Recent Shoreline Comparisons and Analyses." ***Journal of Coastal Research*****. 21.4 (2005): 704-709. Print.**
The National Assessment of Shoreline Change Project is an attempt to standardize methods to determine change in shorelines over time using lidar data and incorporates historical shoreline databases and topography. The purpose of the project is to understand the controlling factors in shoreline movement, to improve the methods of assessing and monitoring said movement, and to facilitate data dissemination.

Morton, Robert A., Noreen A. Buster, and M. Dennis Krohn. "Subsurface Controls on Historical Subsidence Rates and Associated Wetland Loss in South Central Louisiana." ***Transactions Gulf Coast Association of Geological Societies*** **52 (2002): 767-778. Print.**
This paper looks at the connection between hydrocarbon production and wetland loss and land subsidence using historical data to make inferences. The author's evaluation shows that during the highest hydrocarbon production there was a pore-pressure reduction that was followed by high subsistence rates. This may have led to, according to the researchers, a movement of fault lines due to rapid fluid extraction and reduced pore-pressure. The authors determine there is a further need to collect data using releveling surveys and analysis of additional water level data to determine if there is a correlation between the reduction of rates of induced subsidence have decreased since rates hydrocarbon production have decreased in the areas targeted for the study.

Piazza, Bryan P., Patrick D. Banks, and Megan K. La Peyre. "The Potential for Created Oyster Shell Reefs as a Sustainable Shoreline Protection Strategy in Louisiana." ***Restoration Ecology*** **13.13 (2005): 499-506. Print.**
This publication is on a study that pertained to the potential use of oyster shell to create a sustainable reef to protect shorelines from further erosion. Oyster shell when used as reef material was successful in reducing shoreline retreat in low wave energy sites according to the study but was found less effective when shorelines experienced high wave energy. There are advantages to utilizing oyster shell as a protective measures against erosion, the first of which is that oysters are native to coastal Louisiana and second oyster shell is lighter than traditional methods such as limestone that experience settling in the soft sediment and will at times need to be added to so that the reef can maintain effectiveness. Another advantage the researchers describe is the sustainability over time. The reefs were seen to attract new growth in the form of oyster spat indicating the natural reefs such as these can promote recruitment that be beneficial both in the reduction of wave energy on the shoreline and providing a ecological value in water quality and habitat creation. The

drawbacks of a large-scale project may be in the availability of enough shell to be effective due to current uses of oyster shell in other industries such as road building and as a supplement in poultry feed.

Ranasinghe, R., M. Larson, and J. Savioli. "Shoreline response to a single shore-parallel submerged breakwater." ***Coastal Engineering*****. 57. (2010): 1006-1017. Print.**
This paper by Ranasinghe et al. is further research on submerged breakwaters using theoretical analysis and numerical modeling that was suggested in a previous paper *Shoreline response to submerged stuctures: A review* by Ranasinghe, Roshanka, and Ian L. Turner. This is research is an attempt to bridge the gap of knowledge on the effects of submerged breakwaters. There are many submerged structures already in place and to attempt to study them on the ground is cost prohibitive therefore the authors suggest numerical modeling as an alternative. Their conclusions are hindered by the lack of prototype data that is available but their results indicate irrespective of the angle of wave incidence, the mode of shoreline response to a SBW primarily depends on the relative magnitudes of the non-dimensional factors: water depth, water depth at crest of structure, length of structure, and the shape parameter but the dependency cannot be determined currently.

Recio, Juan, and Hocine Oumeraci. "Effect of deformations on the hydraulic stability of coastal structures made of geotextile sand containers." ***Geotextiles and Geomembranes*****. 25. (2007): 279-292. Print**
Geotextile sand containers (GSC's) are used in many applications to protect shorelines and to reinforce sand dunes. The author cites there are many ongoing studies on wave action and GSC's. But due to deformation of GSC's over time the hydraulic stability is negatively impacted. These researchers set out to provide a stability formula to account for "this effect and the associated processes which have led to the observed failures. The researchers used scale model test to simulate deformations and displacement to study wave induced forces, internal movement of sand in the containers, and underlying factors that lead to displacement and deformation of GSC's. The researchers overall goal is to provide a general stability formula that can be applied to the GSC's that are used to protect the shorelines.

Rijn, L.C. van "Coastal erosion and control." ***Ocean & Coastal Management*****. 54. (2011): 867-887. Print.**
Rijn's paper on coastal erosion has sought to use a concept called coastal cells "which are defined as coastal compartments containing the complete cycle of erosion, deposition, sediment sources and sinks and the transport paths," to define the "mechanisms causing chronic erosion and fluctuation erosion related to coastal variability." Both small-scale field sites and numerical modeling were used to assess the effectiveness of either using soft sediment nourishment or hard structure for control erosion. He discusses the pros and cons of each as a remedy. Both soft sediment and hard structure have their place but to be effective the method chosen must be site specific.

Voordet, M. ten, J.S. Antunes do Carmo, and M.G. Neves. "Designing a Preliminary Multifunctional Artificial Reef to Protect the Portuguese Coast." *Journal of Coastal Research*. 25.1 (2009): 69-79. Print.
This is research on designing of a multifunction artificial reef that is delta shaped with a specified angle and slope to enhance surf-ability, protect the valuable beach for tourism, while not obstructing the picturesque view along the Portuguese coast. This paper and research seems slanted away from actually protecting the coastline towards creating new habitat for surfers although on both accounts they deem the project a success.

Walkden, M.J., and J.W. Hall. "A Mesoscale Predictive Model of the Evolution and Management of a Soft-Rock Coast." *Journal of Coastal Research*. 27.3 (2011): 529–543. Print.
This paper describes the development, behavior, and application of a mesoscale numerical geomorphological model of eroding soft rock and beach shores.Soft-Cliff and Platform Erosion (SCAPE) is a model that is characterized by “long shore, non-uniform, time-stepping hybrid model of soft-shore recession and profile evolution. It is hybrid in that it includes both process descriptions and behavior-oriented representations. It contains a non-equilibrium profile model (an equilibrium form is not explicitly imposed), which interacts with an equilibrium (one-line) beach model.” This model is a predictive tool that can show “the long shore effects of local management decisions can be represented, so that regional as well as local costs and benefits of coastal-management interventions can be evaluated.”