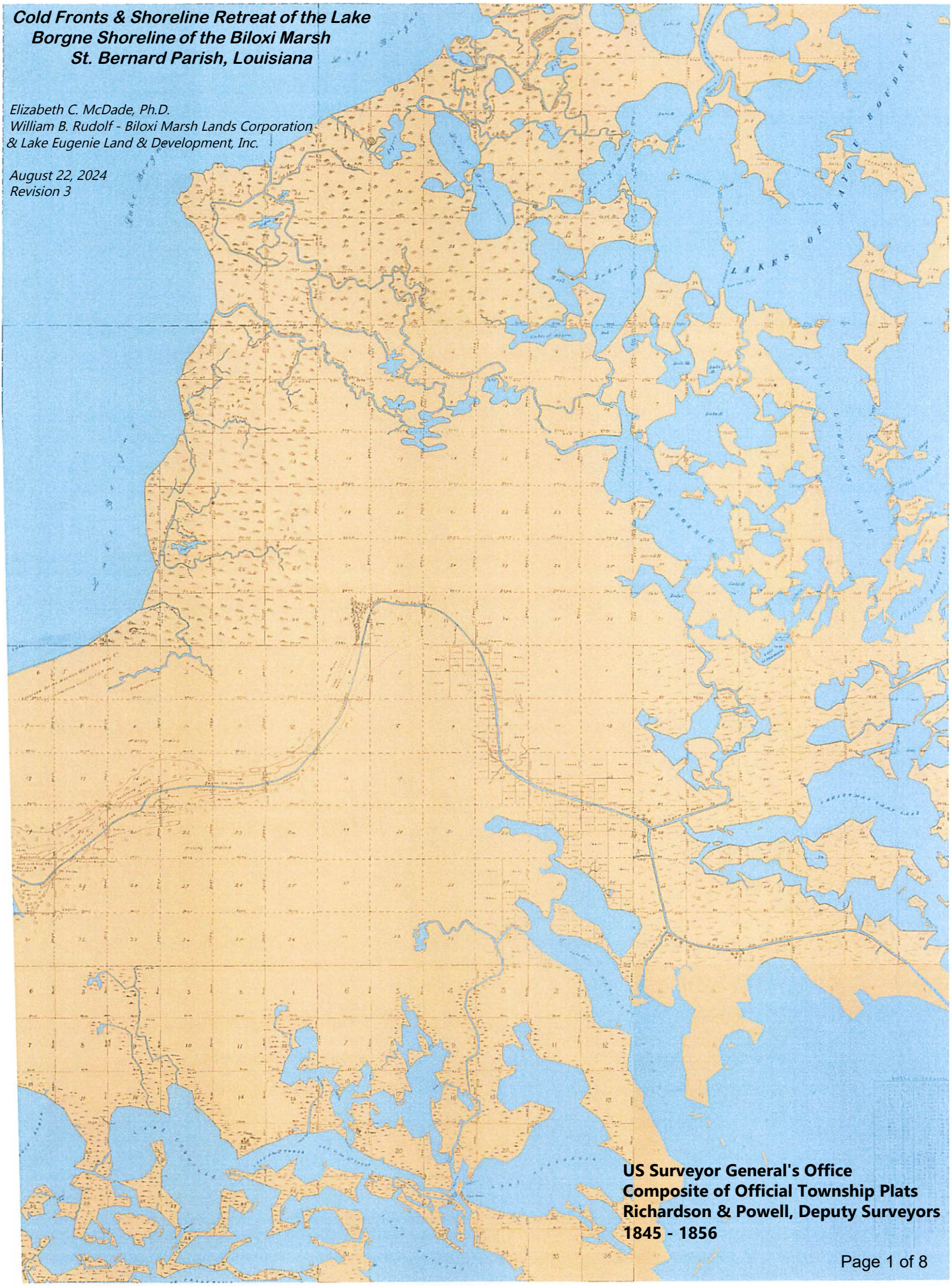
Cold Fronts & Shoreline Retreat of the Lake Borgne Shoreline of the Biloxi Marsh St. Bernard Parish, Louisiana

Elizabeth C. McDade, Ph.D.
William B. Rudolf - Biloxi Marsh Lands Corporation & Lake Eugenie Land & Development, Inc.

August 22, 2024
Revision 3



US Surveyor General's Office
Composite of Official Township Plats
Richardson & Powell, Deputy Surveyors
1845 - 1856

Cold Fronts & Shoreline Retreat of the Lake Borgne Shoreline of the Biloxi Marsh
St. Bernard Parish, Louisiana
EFFECTS AND SOLUTIONS USING SHORE-PARALLEL ROCK DIKES

Each year, the western Biloxi Marsh along Lake Borgne is losing a significant amount of marsh lands due to peripheral shoreline erosion as well as internal erosion (internal bayous, ponds and other interval waterways enlarging). BOTTOM LINE: The Biloxi Marsh is coming apart from the "outside in" and the "inside out".[1] Armoring the Lake Borgne shoreline is a critical component of ensuring the long-term viability of the Biloxi Marsh that will in turn, ensure the long-term viability of other restoration projects in and around the Biloxi Marsh. Without immediate stabilization of the Lake Borgne shoreline, the Biloxi Marsh long-term existence is in jeopardy.[2]

Predominant Causation: The western Biloxi Marsh has approximately 15 miles of unprotected shoreline oriented in the north-south direction along Lake Borgne. The dramatic change in salinity and hydrology caused by construction and operation of the Mississippi River Gulf Outlet channel (MRGO, late 1950s-2009) accelerated shoreline retreat due to, including other detrimental effects of the MRGO to the ecosystem, the loss of protection provided by the natural *Rangia* clam shell berm.[3] This shoreline is battered relentlessly during multiple cold fronts every year, resulting in up to ~50 ft/yr of shoreline retreat and new hydrologic connections that break up the interior marsh.[4] Rock barriers in southern Lake Borgne, particularly CPRA PO-72, are a proven shoreline protection method that demonstrate the effectiveness of rocking the Lake Borgne shoreline.

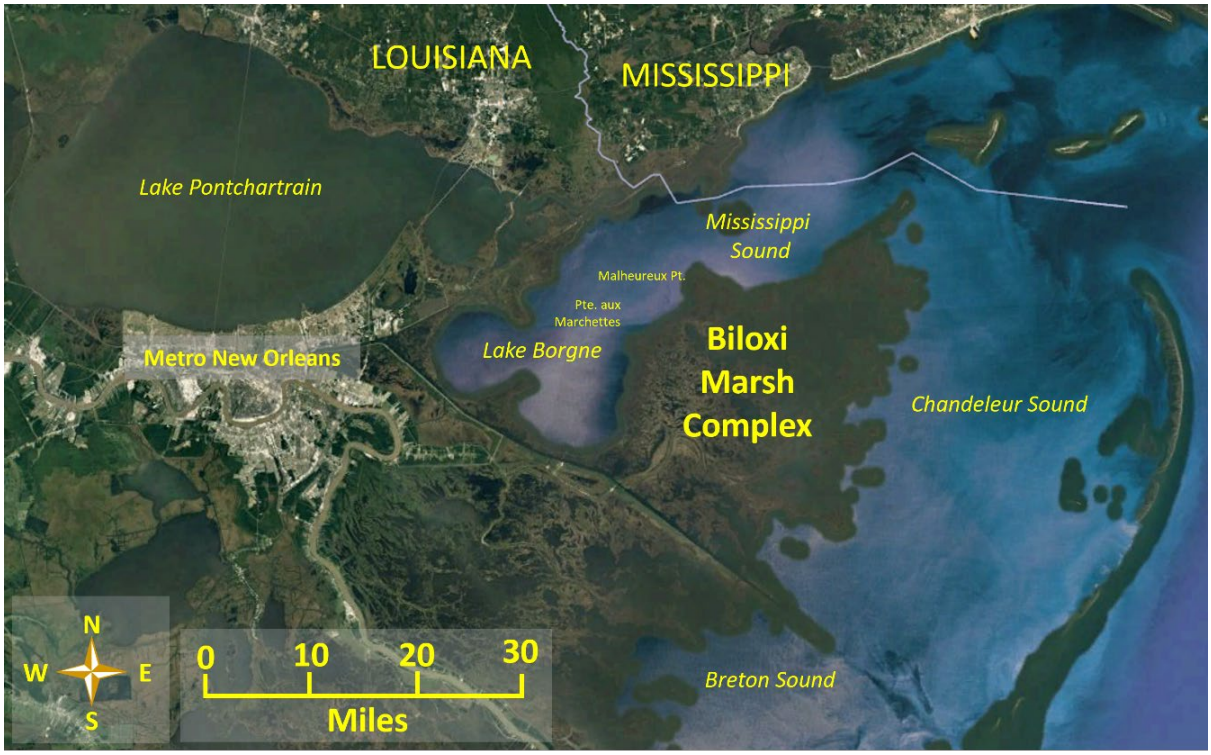


Figure 1: Biloxi Marsh is a 700 sq mile north-south peninsular land mass about 35 miles east of Metro New Orleans surrounded by water on four sides: Chandeleur, Breton, and Mississippi Sounds, and Lake Borgne.[5] It is an important storm buffer for the city of New Orleans because friction from the emergent marsh helps to attenuate and slow waves from occasional Atlantic season hurricanes and tropical storms.[6] Biloxi Marsh also provides major and essential low-brackish to salt-marsh habitat, fisheries, and oyster beds used for recreational and commercial purposes not only for Louisiana, but the entire mid-Gulf coast region.[7]

[1] Couvillion et al. 2016, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021.
[2] Biloxi Marsh Lands Corp. 2006, 2017, 2019, Couvillion et al. 2016, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021.
[3] Poirrier 2012, 2019, BLMC Comments to CPRA Master Plans 2017, 2019, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021.
[4] CWPPRA PPL-33 Biloxi Marsh SP WVA 2023, Couvillion et al. 2016, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021.
[5] Rudolf, W. B. (2017). Comments: DRAFT 2017 Coastal Master Plan.
[6] Deitrich et al. 2011, Resio and Westerink 2008, NOAA National Hurricane Center, Lopez 2006, 2009.
[7] Biloxi Wildlife Management Area https://www.wlf.louisiana.gov/page/biloxi

BILOXI MARSH MAJOR LAND LOSS - Overview

1. Biloxi Marsh, a north-south oriented peninsula (~40 miles north to south; ~25 miles east to west) located in eastern St. Bernard Parish (Figure 1), suffers from significant peripheral erosion particularly along the western shore of the Biloxi Marsh with Lake Borgne,[8] and internal erosion within the marsh along tidally connected channels.[9]

2. The geographic position of the Biloxi Marsh as a north-south peninsula exposes its western shoreline with Lake Borgne to wind-driven wave and tidal action making this shoreline particularly susceptible to erosion and degradation from cold fronts.[10]

3. Cold fronts pass 30-40 times annually,[11] or about every 5 to 8 days mostly during the winter months and have a large cumulative effect on land loss in the Biloxi Marsh while tropical storm events affect the 100 only once every 5 years on average.[12]

4. The shoreline of the Biloxi Marsh along Lake Borgne is retreating at alarming rates from wave fetch erosion caused during numerous annual cold front passages. Accompanying each cold front passage there is also a phenomenon known as "coastal flushing".[13] This "coastal flushing" phenomenon is the result of strong onshore winds (E-SE-S) prior to each frontal passage that blow water into the Biloxi Marsh (creating abnormally high-water conditions) followed by the passing of the cold front with a wind shift to strong offshore winds (W-NW-N-NE) (Figure 2A.).[14] The offshore winds blow the abnormally high water seaward out of the Biloxi Marsh, lowering water level in the marsh. This is "coastal flushing". This rapid fall in the water levels causes internal marsh erosion (tidal scour) along bayous and pond edges that occurs with the abrupt evacuation of the pre-frontal passage high water.[15] Some cold fronts are associated with strong low pressure storm systems that increase land loss, exacerbating the foregoing erosional process by increasing the duration of the event and influencing water levels by variations in barometric pressure.[16]

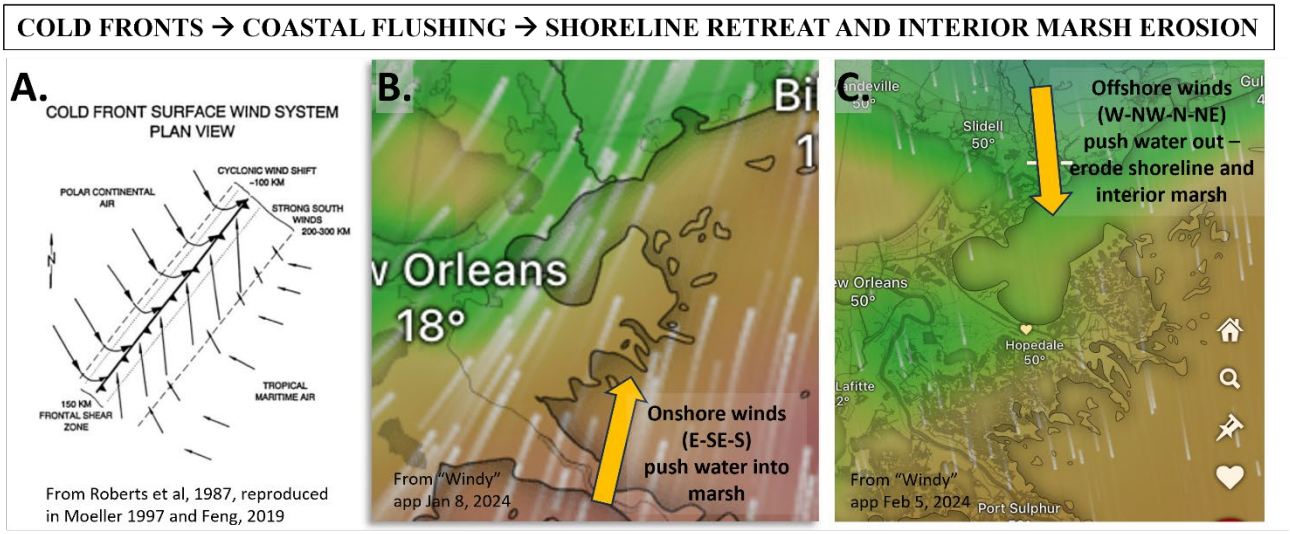


Figure 2: Cold fronts are a frequent winter month weather event in Louisiana. As a north-south oriented peninsula, the Biloxi Marsh is especially vulnerable to detrimental effects from cold fronts as they move across the marsh platform with large shifts in wind direction and barometric pressure (A.). Before the front passes (B.), onshore pre-frontal winds move water into the marsh, raising water level. After frontal passage (C.), offshore post-frontal winds move water out of the marsh, lowering water level and eroding the west-facing shoreline and interior channels, and depositing sediment landward.[17]

[8] Kemp et al, 2021, Day et al, 2019, Trosclair, 2013, CWPPRA PPL-33 Biloxi Marsh SP WVA 2023
[9] Couvillion et al. 2016, Day et al., 2019
[10] Trosclair 2013, Grout 2021, CWPPRA PPL-2023 WVA
[11] Roberts et al. 1987, Moeller et al, 1993, Feng 2009, Cao et al. 2020, Guo et al. 2020, Kim et al. 2020
[12] NOAA National Hurricane Center
[13] Roberts et al 1987, Mossa and Roberts 1990, Moeller et al 1993, Feng 2009, Feng and Li 2010, Li et al. 2011, Kim et al. 2020
[14] Roberts et al 1987, Mossa and Roberts 1990, Moeller et al 1993, Feng 2009, Feng and Li 2010, Li et al. 2011, Kim et al. 2020
[15] Roberts et al 1987, Mossa and Roberts 1990, Moeller et al 1993, Feng 2009, Feng and Li 2010, Li et al. 2011, Kim et al. 2020
[16] Trosclair 2013, Cao et al. 2020, Guo et al. 2020
[17] Roberts et al 1987, Mossa and Roberts 1990, Moeller et al 1993

5. In the pre-frontal phase before a cold front passes, onshore winds push water into the Biloxi Marsh for several days raising water levels in the marsh (Figure 2B.). Winds then shift to an offshore direction as the frontal shear zone passes (Figure 2C.). These post-frontal winds push water back seaward through the marsh, rapidly lowering water levels. Meanwhile, strong wind-driven waves batter the Lake Borgne shoreline during the post-frontal phase, causing peripheral erosion which in turn creates more openings that expose the internal marsh to increasing effects of internal tidal scour.[18]

6. Shoreline retreat accelerated by cold front passage is the reason that the primary land loss in the Biloxi Marsh occurs on the leeward side (western shoreline with Lake Borgne), not the windward (Chandeleur Sound shoreline.[19] Most coastal protection plans emphasize subsidence and marsh loss from tropical systems in decision-making process for projects, concerns that are less important in the Biloxi Marsh than the obvious peripheral erosion and its cascading detrimental effects along the Lake Borgne shoreline.[20] There is a clear need to recognize and manage the predictable land loss caused during the passage of multiple annual cold fronts. CWPPRA PO72 clearly demonstrates that shoreline and internal land loss can be stopped with shoreline protection.[21]

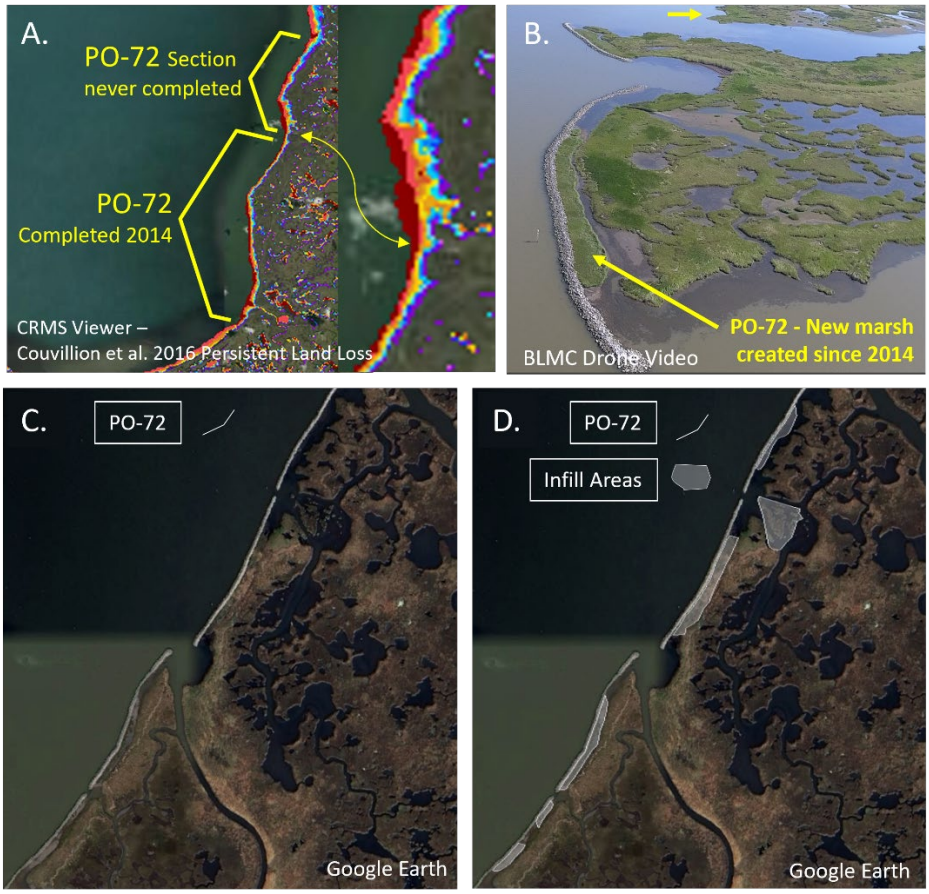


Figure 3: (A.) CPRA PO-72 was completed in 2014 without building to full project extent, but almost immediately had positive effect on the Biloxi Marsh shoreline where it was installed, arresting shoreline retreat and, (B.) building new land behind the barrier. [22] *(C.) Sections of the Biloxi Marsh protected by rock barriers installed as CPRA PO-72 in 2014. (D.) New, healthy marsh quickly formed as "infill" behind the barriers, likely built on a substrate of sediment deposited during the post-frontal stage of cold fronts.* [23]

[18] Day et al. 2019, Lane et al. 2020, Kemp et al. 2021, CWPPRA PPL-33 Biloxi Marsh SP WVA 2023
[19] Feng 2009, Feng and Li 2010, Li et al. 2011, Trosclair, 2013, Day et al, 2019, Lane et al. 2020, Kemp et al. 2021
[20] CPRA Master Plan 2012, 2017, BLMC Comments to CPRA Master Plans 2017, 2019, 2023, Byrnes et al. 2019, BMLC Comments to CPRA Master Plans 2017, 2019, Byrnes et al. 2019, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021
[21] Day et al. 2019, Lane et al. 2020, Kemp et al. 2021, CWPPRA PPL-33 Biloxi Marsh SP WVA 2023
[22] Couvillion et al., 2016, CWPPRA PPL-33 Biloxi Marsh SP WVA 2023. Google Earth Pro historical images, Day et al. 2019, Lane et al 2020, Kemp 2021
[23] Roberts et al. 1987, Moeller et al. 1993, Feng 2009, Feng and Li 2010, Li et al. 2011

7. Originally designed, planned, permitted, and funded as a ~7-mile barrier (Figure 3A.),[24] CPRA PO-72 is ~4 miles of rocked shoreline installed in 2014 along the southeast Lake Borgne shoreline from Jancke's Ditch to south of Bayou Grande. The barrier has worked very well to protect the shoreline from peripheral erosion from multiple cold fronts each year as designed,[25] clearly demonstrating the ability of rocked barriers to stop shoreline retreat in eastern Lake Borgne.[26] As an extra benefit - new marsh has been created inland from the PO-72 (Figures 3B.to 3D.)[27] – most likely built on a substrate of lake bottom-derived sediment[28] carried into place by breaking waves during the post-frontal phase of the same cold fronts that erode unprotected Lake Borgne shoreline.[29]

   An extension of this type of rocked shoreline barrier is exactly what is needed to protect the additional ~15 miles of Biloxi Marsh shoreline from the end of PO-72 to at least the northern tip of Malheureux Pt. and can be expected to have similar positive results based on nearby project success in stopping shoreline retreat and providing protection for deposition of substrate that encourages new marsh growth inland from the rock barriers.

Priority Projects to Protect & Stabilize the Biloxi Marsh

- **The Biloxi Marsh's orientation as a north-south peninsula with a west-facing shoreline, combined with peripheral erosion from cold front driven waves and inland coastal flushing as the main causes of land loss makes Biloxi Marsh a prime candidate for cost efficient armoring of the Lake Borge shoreline with a simple rock revetment.[30]**

- **Armoring the Lake Borgne shoreline from the current termination of CPRA PO-72 extending ~15 miles to at least, the northern tip of Malheureux Pt. is critical to save this important marine estuary and accompanying resources. We cannot over emphasize the need to implement this armoring as soon as possible.[31]**

- **Implementation of armoring the Biloxi Marsh shoreline is expected to greatly reduce shoreline retreat, thus reducing the openings between Lake Borgne and the interior marsh ("hydrologic connectivity"). This will prevent both peripheral and internal erosion.[32]**

- **In addition to stopping shoreline retreat and reducing hydrologic connectivity, shoreline armoring will capture lake-derived sediment forming a substrate for new marsh inland of the rock barrier.[33]**

[24] CPRA Biloxi Marsh Shoreline Design and As-Built Project Documents, CWPPRA PPL-33 Biloxi Marsh SP WVA 2023.
[25] Accardo 2022, PO-72 Annual Inspection Report, CWPPRA PPL-33 Final Project Proposals, CWPPRA PPL-33 Biloxi Marsh SP WVA 2023
[26] CWPPRA PPL-33 Biloxi Marsh SP WVA 2023, Google EarthPro Historical images,
[27] Google EarthPro Historical images, Couvillion 2016, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021
[28] Day et al. 2019, Lane et al. 2020, Kemp et al. 2021, Couvillion et al. 2016
[29] Roberts et al. 1987, Moeller et al. 1993, Feng 2009, Feng and Li 2010, Li et al. 2011, Google Earth Pro historical images, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021
[30] King et al 2006, Rudolf 2019, CWPPRA 2023 PPL-33 Biloxi Marsh SP WVA
[31] King et al 2006, CPRA Master Plan 2012, 2017, 2023, BLMC Comments to CPRA Master Plans 2017, 2019, 2023, Rudolf 2019, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021
[32] Day et al. 2019, Lane et al. 2020, Kemp et al. 2021
[33] Google EarthPro Historical images, CWPPRA 2023 PPL-33 Biloxi Marsh SP WVA, Day et al. 2019, Lane et al. 2020, Kemp et al. 2021

BIBLIOGRAPHY

Acarrdo, M. (2022). 2022 Annual Inspection Report for the Biloxi Marsh Shoreline Protection Project (p. 18). https://cims.coastal.louisiana.gov/RecordDetail.aspx?Root=0&sid=24912

Biloxi Marsh Shoreline Protection PO-72 Project Details. (N/A). Biloxi Marsh Shoreline Protection PO-72 Project Details. https://coastal.la.gov/project/biloxi-marsh-shoreline-protection/#tabs1-overview

Biloxi Marsh Shoreline Protection PO-72, Project Documents. (2010, 2014). Biloxi Marsh Shoreline Protection PO-72, Project Documents. https://coastal.la.gov/project/biloxi-marsh-shoreline-protection/#tabs1-overview

Byrnes, M., Britsch, L. D., Berlinghoff, J. L., & Johnson, R. (2019). Determining Recent Subsidence Rates for Breton Sound and Eastern Pontchartrain Basins, Louisiana: Implications for Engineering and Design of Coastal Restoration Projects (Prep. for LA Coastal Protection and Restoration Authority, p. 28) [Final Report]. Applied Coastal in co-operation with CDM Smith.

Cao, Y., Li, C., & Dong, C. (2020). Atmospheric Cold Front-Generated Waves in the Coastal Louisiana. Journal of Marine Science and Engineering, 8(11), 22.

Chaichitehrani, N., Li, C., Xu, K., Allahdadi, M. N., Hestir, E. L., & Keim, B. D. (2019). A numerical study of sediment dynamics over Sandy Point dredge pit, west flank of the Mississippi River, during a cold front event. Continental Shelf Research, 183, 38–50. https://doi.org/10.1016/j.csr.2019.06.009

Couvillion, B. R., Beck, H., Schoolmaster, D., & Fischer, M. (2017). Land area change in coastal Louisiana (1932 to 2016) (Report 3381; Scientific Investigations Map). USGS Publications Warehouse. https://doi.org/10.3133/sim3381

CPRA. (n.d.). Biloxi Marsh Shoreline Protection PO-72 Project As Built Drawings (p. 25).

CPRA. (2017a). CMP 2017 Appendix D: Planning Tool (2017 Coastal Master Plan, p. 117). Coastal Protection and Restoration Authority. https://coastal.la.gov/wp-content/uploads/2017/04/2017-Coastal-Master-Plan_Web-Single-Page_CFinal-with-Effective-Date-06092017.pdf

CPRA. (2017b). Louisiana's Comprehensive Master Plan for a Sustainable Coast 2017 (2017 Coastal Master Plan, p. 184). Coastal Protection and Restoration Authority. https://coastal.la.gov/wp-content/uploads/2017/04/2017-Coastal-Master-Plan_Web-Single-Page_CFinal-with-Effective-Date-06092017.pdf

CPRA. (2021). ICM- High Tide Modeling Approach (Attachment H-2; Coastal Master Plan 2023, p. 138). Coastal Protection and Restoration Authority. https://coastal.la.gov/wp-content/uploads/2023/08/H2_ICM-HighTideFloodingApproach_Feb2021_v3.pdf

CPRA. (2023). Louisiana's Comprehensive Master Plan for a Sustainable Coast 2023 (2023 Coastal Master Plan, p. 101). Coastal Protection and Restoration Authority. https://coastal.la.gov/wp-content/uploads/2023/06/230531_CPRA_MP_Final-for-web_spreads.pdf

CWPPRA. (2023). Candidate Project for th 33rd Priority Project List of the Coastal Wetlands Planning, Protection and Restoration Act (p. 12) [Final Project Information Sheet for Wetland Value Assessment].

CWPPRA. (2024, January 20). Wetland Value Assessments. Stats for Authorized Projects. https://lacoast.gov/new/Projects/WVA.aspx#ctl00_ContentPlaceHolder1_panelDeauth

CWPPRA 25th Project Priority List (including Pte. Aux Marchettes). (2015). https://www.mvn.usace.army.mil/Portals/56/docs/environmental/cwppra/PPL/PPL%2025/REGION1FSandPwpts1.pdf?ver=2015-02-23-110441-050

Day, J. W., Kemp, G. P., Lane, R. R., McDade, E. W., Dawers, N., & Rudolf, W. B. (2019). New Information Supporting the Stabilization & Restoration of the Biloxi Marsh Complex A Unique and Distinct Ecosystem (p. 125). http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2019/10/New-Information-Supporting-the-Stabilization-Restoration-of-the-Biloxi-Marsh-A-Unique-and-Distinct-Ecosystem-2.pdf

Dietrich, J. C., Westerink, J. J., Kennedy, A. B., Smith, J. M., Jensen, R. E., Zijlema, M., Holthuijsen, L. H., Dawson, C., Luettich, R. A., Powell, M. D., Cardone, V. J., Cox, A. T., Stone, G. W., Pourtaheri, H., Hope, M. E., Tanaka, S., Westerink, L. G., Westerink, H. J., & Cobell, Z. (2011). Hurricane Gustav (2008) Waves and Storm Surge: Hindcast, Synoptic Analysis, and Validation in Southern Louisiana. Monthly Weather Review, 139(8), 2488–2522. https://doi.org/10.1175/2011MWR3611.1

Feng, Z. (2009). Hydrodynamic response to cold fronts along the Louisiana coast [MS Thesis, LSU]. https://doi.org/10.3390/jmse8110900

Feng, Z., & Li, C. (2010). Cold-front-induced flushing of the Louisiana Bays. Journal of Marine Systems, 82(4), 252–264. https://doi.org/10.1016/j.jmarsys.2010.05.015

Grout, R. A. (2021). Geomorphological responses of Biloxi Marsh platform due to variation in the volume and distribution of marsh-edge shell-ridges during cold-fronts and tropical storms [MS Thesis, University of New Orleans]. https://scholarworks.uno.edu/td/2917

Guo, B., Subrahmanyam, M. V., & Li, C. (2020). Waves on Louisiana Continental Shelf Influenced by Atmospheric Fronts. Nature Scientific Reports, 10:(272). | https://doi.org/10.1038/s41598-019-55578-w

Kemp, G. P., & Day, J. W. (2017). Restoration and Sustainability of the Biloxi Marsh Complex: Comment on the 2017 Comprehensive Master Plan [Report: Prepared for the Biloxi Marsh Corporation]. https://hgu8b3.p3cdn1.secureserver.net/wp-content/uploads/2017/05/G.-Paul-Kemp-and-John-W.-Day-Restoration-and-Sustainability-of-the-Biloxi-Marsh-Complex-Report.pdf

Kemp, G. P., McDade, E. C., Day, J. W., Lane, R. R., Dawers, N. H., & Day, J. N. (2021). Recovery and Restoration of Biloxi Marsh in the Mississippi River Delta. Water, 13(22). https://doi.org/10.3390/w13223179

Kim, J.-Y., Kaihatu, J., Chang, K.-A., Sun, S.-H., Huff, T. P., & Feagin, R. A. (2020). Effect of Cold Front-Induced Waves Along Wetlands Boundaries. Journal of Geophysical Research: Oceans, 125(12), e2020JC016603. https://doi.org/10.1029/2020JC016603

King, K. J., Landry, R. C., McMahon, G., Ellis, J., Moertle, R., Penland, S., Reed, D., Rudolf, W. B., & Suhayda, J. N. (2006). The Biloxi Marsh Stabilization and Restoration Plan (p. 56) [Prepared for: Biloxi Marsh Lands Corporation].

Lane, R. R., Reed, D. J., Day, J. W., Kemp, G. P., McDade, E. C., & Rudolf, W. B. (2020). Elevation and accretion dynamics at historical plots in the Biloxi Marshes, Mississippi Delta. Estuarine, Coastal and Shelf Science, 245, 106970. https://doi.org/10.1016/j.ecss.2020.106970

Li, C., Roberts, H. H., & Stone, G. (2011). Wind, Surge, and Salt-water intrusion into Atchafalaya Bay under offshore winds prior to cold front passage. Hydrobiologia, 658, 27–39.

Lopez, J. A. (2006). The Multiple Lines of Defense Strategy (p. 22). Lake Pontchartrain Basin Foundation.

Lopez, J. A. (2009). Pontchartrain Lines of Coastal Defense (p. 2) [Pamphlet and Map]. Lake Pontchartrain Basin Foundation.

Moeller, C. C., Huh, O. K., Roberts, H. H., Gumley, L. E., & Menzel, W. P. (1993). Response of Louisiana Coastal Environments to a Cold Front Passage. Journal of Coastal Research, 9(2), 434–447.

Mossa, J., & Roberts, H. H. (1990). Synergism of riverine and winter storm-related sediment transport processes in Louisiana's coastal wetland. Gulf Coast Association of Geological Transactions, 40, 635–642.

Poirrier, M. A. (2012). Effects of Closure of the Mississippi River Gulf Outlet on Saltwater Intrusion and Bottom Water Hypoxia in Lake Pontchartrain. Gulf and Carribean Research, 25, 105–109.

Poirrier, M. A. (2019, February 18). Status of Rangia cuneata clams in Lake Borgne Louisiana after closure of the Mississippi River Gulf Outlet. Prepared for: John W. Day on behalf of BMLC. https://hgu8b3.p3cdn1.secureserver.net/wp-content/uploads/2017/05/Poirrier-2019.pdf

Resio, D. T., & Westerink, J. J. (2008). Modeling the Physics of Storm Surges. Physics Today, 61, 33–38.

Roberts, H. H. (1987). Winter storm impacts on the Chenier Plain Coast of southwestern Louisiana. Gulf Coast Association of Geological Socieities, 39, 515–522.

Roberts, H. H., Huh, O. K., Hsu, Rouse, l. L., & Rickman, D. (1987). Impact of cold front passages on geomorphic evolution and sediment dynamics of the complex Louisiana coast. In: Proceedings of a Specialty Conference. May 12-14, 1987, New Orleans, LA.

Rudolf, W. B. (2019, February 28). Leveraging Natural Resilience to Ensure Long-Term Sustainability of the Biloxi Marsh Complex: An Integrated Project. Biloxi Marsh Lands Corp., Lake Eugenie Land & Dev't Inc. https://hgu8b3.p3cdn1.secureserver.net/wp-content/uploads/2017/05/BMC-2023-New-Project-Proposal-FINAL-Submitted.pdf

Stone, G., Liu, B., & Jose, F. (2007). WINTER STORM AND TROPICAL CYCLONE IMPACTS ON THE SHORTTERM EVOLUTION OF BEACHES AND BARRIERS ALONG THE NORTHEASTERN GULF OF MEXICO. Coastal Sediments 2007, 17.

Trosclair, K. (2013). Wave transformation at a salt marsh edge and resulting marsh edge erosion: Observations and modeling [M.S., University of New Orleans]. https://scholarworks.uno.edu/td/1777/

USACE. (2007). Mississippi River—Gulf Outlet Deep-Draft De-Authorization Study (Main Report Vol. 1; p. 265 pp.). US Army Corps of Engineers, New Orleans District. https://www.mvn.usace.army.mil/Portals/56/docs/environmental/MRGO/MRGODeauthorizationFinalReporttoCongress060308.pdf

USACE. (2012). MISSISSIPPI RIVER GULF OUTLET (MRGO) ECOSYSTEM RESTORATION PLAN (p. 285) [FINAL FEASIBILITY REPORT]. US Army Corps of Engineers. https://www.mvn.usace.army.mil/Portals/56/docs/environmental/MRGO/MRGOEcosystemRestorationFinalFeasibilityReportJune2012.pdf

Watzke, D. A. (2004). Short-term evolution of a marsh island system and importance of cold front forcing [MS Thesis, Louisiana State University]. https://repository.lsu.edu/cgi/viewcontent.cgi?article=4138&context=gradschool_theses

William B. Rudolf, Day, J., Kemp, G. P., & McLindon, C. (2017, March 24). Comments: DRAFT 2017 Coastal Master Plan. https://hgu8b3.p3cdn1.secureserver.net/wp-content/uploads/2017/05/BLMC-Comments-to-Coastal-Protection-and-Restoration-Authority-CPRA-2017-Coastal-Master-Plan-CMP.pdf.