- Expert Report -

Effects of the Mississippi River-Gulf Outlet on Coastal Wetlands in Southeastern Louisiana

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Submitted by:

John W. Day, Jr.[1] and Gary P. Shaffer[2]

[1]Department of Oceanography and Coastal Sciences
Louisiana State University, Baton Rouge, LA 70803
[2]Department of Biological Sciences, SLU-10736
Southeastern Louisiana University, Hammond, LA 70402

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This Expert Report is submitted on behalf of the Plaintiffs in *Robinson v. United States* with respect to the Section 702c immunity issues. We reserve the right to supplement this Expert Report upon receipt of documents produced by the U.S. Army Corps of Engineers. As detailed below, it is our opinion that (1) baldcypress – water tupelo (*Taxodium distichum – Nyssa aquatica*) swamps offer excellent hurricane protection, while the intermediate and brackish marshes, and open areas created by the Mississippi River-Gulf Outlet (MR-GO) are much more inferior with regard to wind- and storm-surge reduction; and (2) the construction of the MR-GO, the severing of the Bayou La Loutre Ridge, and the steady influx of salt water into the baldcypress – water tupelo swamps in Orleans and St. Bernard Parishes quickly and directly killed much of this previously-thriving, extensive habitat.

Qualifications

Dr. John Day is a professor in the Department of Oceanography and Coastal Sciences at Louisiana State University who has worked on coastal wetland issues in Louisiana for the past 35 years. For the last 20 years, he has studied the complex mechanisms responsible for wetlands loss in coastal Louisiana as well as techniques to restore wetlands, including baldcypress – water tupelo swamps. The School of the Coast and Environment at LSU has an international reputation for the study and management of coastal and wetland ecosystems.

Dr. Gary Shaffer is a professor in the Department of Biological Sciences at Southeastern Louisiana University. He has decades of research experience on wetland systems. Dr. Shaffer is the Departments biostatistician, was appointed as the initial Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) Science Advisor for the Lake Pontchartrain Basin (currently re-appointed), and helped devise potential restoration projects for the Lake Pontchartrain Basin in CWPPRA, Coast 2050, and LCA programs. He also assisted The Nature

Conservancy and the Lake Pontchartrain Basin Foundation in devising specific restoration programs for the Basin. Over the past 8 years, his lab has been conducting a major study on the health and restoration of baldcypress – water tupelo swamps of the Lake Pontchartrain Basin.

Swamps for Hurricane Protection

In terms of storm-surge and wind-damage reduction, baldcypress – water tupelo swamps are far superior to most other wetland habitat types. Only live oak (*Quercus virginica*) and palms are more resistant to wind throw (i.e., blow down) than baldcypress and water tupelo (Williams et al. 1999). Cypress – tupelo swamps faired far better than other forest types in Hurricanes Camille (Touliatos and Roth 1971), Andrew (Doyle et al. 1995), and Hugo (Gresham et al. 1991, Putz and Sharitz 1991). In addition, fresh, intermediate, and brackish marshes suffered vastly greater loss in Hurricanes Katrina and Rita than did cypress – tupelo swamps (Barras 2006). Katrina caused wind throws of up to 80% of the bottomland hardwood forests of the Pearl River Basin (with an estimated loss of 900-million board feet of lumber in the Honey Island swamp alone), while contiguous swamps remained largely intact (Peggy McClain, LDAF, pers. comm.; also compare pre- and post Katrina aerial imagery of LADNR's website).

Although baldcypress – water tupelo swamps are extremely resistant to wind throw and deep flooding, they are far less resistant to saltwater intrusion (Penfound and Hathaway 1938), and to stressors coupled with salinity stress (Shaffer et al. 2007). Therefore, they require a reliable source of fresh water for system flushing following tropical storm events and during droughts. In stark contrast to this, the MR-GO brought the swamps contiguous with Orleans and St. Bernard Parishes a steady influx of lethal salt water.

Prior to construction of the MR-GO, the environmental setting for coastal wetlands in southeastern Louisiana was significantly different than at the present time. The area under

consideration includes wetlands that are now deemed the Central Wetlands Unit (CWU), around Lake Borgne, and north and south of the Bayou La Loutre natural levee ridge. Prior to the construction of the MR-GO, there were extensive baldcypress – water tupelo swamps in the CWU and adjacent to the Bayou La Loutre Ridge. The semi-enclosed and protected nature of this area—and the exclusion of deadly salt water— allowed the survival of these swamps (see historic photos in Penland Report). Water budget analyses for southeastern Louisiana show that about one third of rainfall remains after evaporation (Brantley 2005, Shaffer and Day 2007). Thus, there was sufficient fresh water to maintain the baldcypress – water tupelo swamps in the CWU, so long as the system did not have a direct input of salt water. Greater than 12,000 acres of the swamps in the CWU were killed shortly after the opening of MR-GO when the U.S. Army Corps cut through the natural ridge at Bayou La Loutre and allowed salt water to move up the tidewater channel and into the Central Wetlands Unit (Team Louisiana 2007). Tens of thousands of wetland acres were subsequently destroyed by the MR-GO over the succeeding decades leading up to Hurricane Katrina (Team Louisiana 2007).

Negative Effects of Saltwater Intrusion

The dangers of increasing salinity in a wetland, including baldcypress – water tupelo swamps, are three-fold: direct osmotic imbalance, salt toxicity, and production in the soils of highly toxic sulfides. Salt water contains sodium chloride ions and when these reach concentrations higher than the solutes in plant cells, fresh water escapes from the plant through osmosis and uptake of fresh water ceases. In essence, the salt-intolerant vegetation is experiencing “drought” conditions (Mendelssohn and Burdick 1988). Plants also absorb ions such as sodium from salt water and these ions may be lethal when in high concentration. Finally, salt water contains a much higher concentration of sulfate than fresh water. In wetlands, the

sulfate, through alternative metabolic pathways of soil microbes (Mitsch and Gosselink 2007), becomes chemically reduced to deadly compounds such as hydrogen sulfide (Mendessohn et al. 1981).

The lethal effects of salt water on freshwater wetland vegetation were known long before the initial construction of the MR-GO (e.g., Penfound and Hathaway 1938). Both the U.S. Fish and Wildlife Service (USFWS) and the Louisiana Department of Wildlife and Fisheries warned the U.S. Army Corps of Engineers (USACE) that construction of the MR-GO could have catastrophic effects on the surrounding flora and fauna. In a report to USACE (the April "1958 Interior Report"), the USFWS predicted that the MR-GO construction "particularly by breaching the natural east-west ridges between fresh/brackish and salt water" would introduce salt water into the wetlands and destroy tens of thousands of acres of marshes and mature baldcypress – water tupelo swamps. In a letter of September 23, 1957, Secretary Seaton of the Department of the Interior made it clear that USACE had not followed the protocol put forth in the Wildlife Coordination Act of August 14, 1946 (60 Stat. 1080), and requested funds to model potential impacts of the MR-GO (Team Louisiana 2007). Modeling funds were not granted and, when the USACE finally modeled MR-GO scenarios (USACE 1963), a salinity increase of 4-6 ppt (lethal to cypress – tupelo swamps) was found (Team Louisiana 2007). Furthermore, the USFWS (in their Interim Report on Fish and Wildlife Resources as Related to Mississippi River-Gulf Outlet Project, Louisiana and an Outline of Proposed Fish and Wildlife Studies 1958) recognized the wetlands of coastal Louisiana as "perhaps the densest and richest wild fauna in the world…[with a] flora [that] has narrow salinity range; therefore, desirable production must result from exacting conditions… [and] the 36-foot-deep cut will result in direct changes of salinity…" The USACE

ignored their concerns and began construction, or perhaps better put, massive wetlands destruction.

Development of the Mississippi Delta

To understand the problems facing coastal forested wetlands in Louisiana, it is helpful to put forested wetlands into the broader context of the entire Mississippi Delta. During the 20th century, there was a massive loss of coastal wetlands, mostly marshes, in the Mississippi Delta. Most research has focused on marsh loss (i.e., Day et al. 2000, 2007) but recently more attention has been given to the issue of coastal forested wetland loss (Chambers et al. 2005, Shaffer et al. 2007). At present, there are plans for a large-scale effort to restore the Delta, including forested wetlands. To do this, it is necessary to understand both the processes that formed the Delta as well as the forces that led to its deterioration. We will put these processes into a conceptual framework of deltaic ecosystem functioning. This framework is called the pulsing paradigm and will be discussed in more detail later.

The Mississippi Delta, like most deltas, is made up of several interdistributary hydrologic basins that are separated by current or abandoned river distributary channels (Day et al. 2007). The Barataria Basin is a typical interdistributary basin located between the Mississippi River and Bayou Lafourche. The Pontchartrain Basin is located between the Mississippi and Pearl Rivers with Pleistocene uplands north of Lakes Pontchartrain and Maurepas. The study area is part of the larger Pontchartrain Basin. These channels developed in several stages. The Mississippi channel first formed as part of the St. Bernard delta complex between 1000-4000 BP. Remnant ridges of the St. Bernard complex occur in the New Orleans metropolitan area, eastern New Orleans, St. Bernard Parish, and the Lake Borgne area. The Plaquamines-Modern delta complex has been active over the last 1000 years. The Lafourche delta complex functioned from about

3500 years BP until colonial times. It was finally closed off from the Mississippi River at the beginning of the 20th century. The interdistributary ridges prevent almost all exchange between interdistributary basins, but until levee construction there was regular input of river water into the basins, including Pontchartrain and Barataria Basins.

The Mississippi Delta formed over the past 6,000-7,000 years as a series of overlapping delta lobes (Roberts 1997) as sea level stabilized at near its present level after rising more than 100 m from the low stand at the height of the last glacial period about 15,000 years ago. There was an increase in wetland area in active deltaic lobes and wetland loss in abandoned lobes, but there has been an overall net increase in the area of wetlands over the past several thousand years (Shaffer et al. 2005, Day et al. 2007).

A number of factors served to enhance the growth of the Delta and retard its deterioration. With the exception of the first delta lobe (Maringouin), significant parts of all subsequent delta lobes have been incorporated into the current delta as a system of overlapping and interwoven distributary systems. Functioning distributaries, overbank flooding, crevasse splays, and reworking of sands formed a skeletal framework of these natural levee ridges and barrier islands within which the Delta plain has formed (Kesel 1989, Kesel et al. 1992). This framework was critically important in protecting baldcypress – water tupelo swamps and other freshwater wetlands in the study area from saltwater intrusion.

Numerous crevasse splays (i.e., Bonnet Carre), minor (i.e., Bayou Manchac) and major (i.e., the Gentily and Metaerie) distributaries and beach ridges occur in the Pontchartrain Basin. Bayou Manchac was not always a minor stream. Today it is a shallow, dead end channel with low flow. But during historical periods, it carried steamboats between the Mississippi River and Lake Pontchartrain (Keddy et al. 2007). Kniffen (1935) described the upper Manchac as a

raging torrent when fed by the Mississippi floodwaters. Furthermore, floodwaters created natural levees along the flanks of Bayou Manchac and caused a rise in base level of the local floodplain, drowning gullies with Mississippi River alluvium. Ecosystem functioning and sustainability of the Delta is controlled by interactions of the Mississippi River and marine processes (Day et al. 1997). The skeletal framework protected wetlands of the Deltaic plain from erosion and salinity intrusion and slowed interactions between fresh water and salt water parts of the Delta. This is especially important for wetlands of the upper Pontchartrain Basin.

Until modified by human activity, many of the distributaries continued functioning, delivering fresh water, sediments, and nutrients to large areas of the Delta plain. Fresh water forms a buffer against salinity intrusion, and provides mineral sediments, nutrients, and other materials, such as iron, that sustain healthier more productive wetlands. The distributary network was very efficient in sediment retention and about 25% of sediment flux was retained in the Delta (Kesel et al. 1992, Tornquist et al. 2007). Because of the widespread freshwater input and the protection afforded by the skeletal network, floating marsh developed into a common marsh type. Riverine input was important for coastal forested wetlands for several reasons. Freshwater input was a buffer against saltwater intrusion, nutrients increased productivity, mineral sediments strengthened soils and helped build up the elevation of the land, and iron detoxified sulfides, the byproducts of anaerobic metabolism.

Delta Deterioration

An understanding of the causes of wetland loss is important not only for a scientific appreciation of the mechanisms involved, but also so that effective management plans can be developed to restore theMississippi Delta (see Boesch et al. 1994, 2006, and Day et al. 2000, 2007, Tornquist et al. 2007 for reviews of these issues). In essence, human activity caused a

reduction in the forces that lead to delta growth and an enhancement of forces that lead to delta deterioration. A number of factors led to the massive loss of wetlands.

- Flood-control levees along the Mississippi River resulted in the elimination of riverine input to most of the Delta (Boesch et al. 1994, Day et al. 2000, 2007).
- In addition to the flood-control levees, most active distributaries were closed (i.e., Bayou Lafourche in 1900 and Bayou Manchac much earlier), crevasses have been mostly eliminated, and the river mouth was made more efficient for navigation. This has resulted in the loss of most river sediments directly to deep waters of the Gulf of Mexico.
- There also has been a reduction of the suspended sediment load in the Mississippi River caused by dam construction upstream (Kesel 1988, 1989). As a result of these activities, the forested wetlands of the Pontchartrain Basin have been cut off from river input for over a century.
- Within the Delta, pervasive altered wetland hydrology, mostly caused by canals, is another important factor contributing to wetland loss. Canals, originally dredged for drainage and navigation, are now overwhelmingly linked to the petroleum industry. Drilling access canals, pipeline canals, and deep-draft navigation channels have left a dense network of about 15,000 km of canals in the coastal wetlands. Although canals are estimated to comprise about 2.5 percent of the total coastal surface area, their destructive impact has been much greater (Turner et al., 1982, Turner 1997, Day et al. 2000).
- Spoil banks, composed of the material dredged from the canals, interrupt sheet flow, impound water, and cause deterioration of wetlands. Long, deep navigation canals—like the MR-GO—that connect saline and freshwater areas tend to lessen freshwater retention time, and allow greater inland penetration of salt water. The MR-GO is an infamous case

of this destructive process. Spoil banks from dredging (as along South Slough just south of Ponchatoula), highway embankments (as along I-55), access roads and drainage canals (e.g., South Slough, Reserve Relief Canal, Hope Canal) have caused much of the area to be semi-impounded with a greatly reduced overland flow hydrology (Shaffer and Day 2007).

In summary, there is a broad consensus that wetland loss is a complex interaction of a number of factors acting at different spatial and temporal scales (e.g., Turner and Cahoon 1987, Day and Templet 1989, Boesch et al. 1994, Day et al. 1995, 1997). Day et al. (2000, 2007) concluded that isolation of the Delta from the Mississippi River by levees was perhaps the most important factor for the Delta as a whole. More locally, the MR-GO greatly accelerated and contributed to the marsh and baldcypress – water tupelo swamp loss in the Pontchartrain and Breton Sound Basins by the introduction of salt water into this sensitive ecosystem.

Coastal Forested Wetlands of the Pontchartrain and Breton Sound Basins

Swamps of the Ponthchartrain and Breton Sound Basins have been cut off from the sustaining spring floods of the Mississippi River for over a century and are in varying states of decline (Shaffer et al. 2005, 2007). This decline is often evidenced by dead and dying trees. This is dramatically the case in the Central Wetlands Unit in Orleans and St. Bernard Parishes. Before the construction of the MR-GO, there were tens of thousands of acres of healthy baldcypress – water tupelo swamp in this area (Team Louisiana 2007). It was sustained by a combination of freshwater surpluses and extensive wetlands and ridges that slowed or prevented saltwater intrusion from the Gulf of Mexico.

Although baldcypress – water tupelo swamps are extremely resistant to wind throw and deep flooding, they are far less resistant to saltwater intrusion and multiple stresses coupled with

salinity stress. They therefore require a reliable source of fresh water for system flushing following tropical storm events and during droughts. The MR-GO provided the exact opposite, causing extensive loss of the baldcypress – water tupelo swamps of the Central Wetlands Unit (CWU) by serving as a constant saltwater intrusion conduit for more than four decades.

Conditions Prior to MRGO Construction

Prior to the construction of the MRGO, the study area was starkly different than it is now. Wetlands were much more extensive than now and, in particular, there were, as noted, tens of thousands of acres of healthy baldcypress – water tupelo swamps in the CWU. The Bayou La Loutre Ridge and other minor ridges were mostly intact. The cypress – tupelo swamp grew in the entire wetland area bordering the developed areas of St. Bernard Parish and Orleans Parish east of the IHNC.

Prior to the construction of the MR-GO, the Bayou La Loutre Ridge was an effective natural barrier against saltwater intrusion. Rainfall in the area north of Bayou La Loutre (and perhaps inflow from the GIWW) provided a relatively constant source of fresh water that protected the baldcypress – water tupelo swamps from salt water. The condition and extent of wetlands in the study area—before and after the MR-GO's construction—has been documented (*see, e.g.*, Expert Report of Dr. Patrick Shea Penland). The nearly complete loss of baldcypress – water tupelo swamps due to saltwater intrusion is clearly evident.

Effects of the MR-GO Construction

The construction of MR-GO directly caused the destruction of tens of thousands of acres of wetlands and led to the indirect death of tens of thousands of additional acres of wetlands. Following the opening of MR-GO, there were significant increases in salinity in the area north of the Bayou La Loutre Ridge. This had a dramatic affect on fresh water and low salinity wetlands.

Salinity killed tens of thousands of acres of baldcypress – water tupelo swamps in the CWU alone. As discussed above, this salt kill was predicted by state and federal agency personnel prior the construction of the MR-GO.

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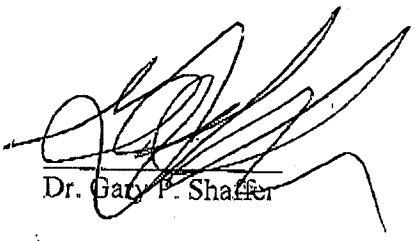
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Dr. John W. Day, Jr.



Dr. Gary P. Shaffer

RESEARCH AND PROFESSIONAL EXPERIENCE OF JOHN W. DAY, JR.

Recent Employment

1999-present, Distinguished Professor of Environmental Sciences, Department of Oceanography and Coastal Sciences, Louisiana State University

1980-present, Professor, Department of Oceanography and Coastal Sciences, Louisiana State University

Recent Teaching Experience

1995-present-Ecology and Management of Tropical Estuaries (in Mexico)

1995-present-Mangrove Ecology (taught irregularly)

Other Recent Experience

2000-2001, Visiting Scientist, Cambridge Coastal Research Unit, Dept. of Geography, University of Cambridge, Cambridge, UK.

1979-present, Adjunct Professor, Institute for Marine Sciences and Limnology, Universidad Nacional Autonoma de Mexico

CURRENT GRANT SUPPORT

A proposal to carry out monitoring and evaluate impacts of storm water discharge to coastal wetlands adjacent to the Pointe Aux Chiens pumping station, Terrebonne Parish, Louisiana. Barataria-Terrebonne National Estuary Program. $213,870. 9/01/02 – 8/31/04. J. Day and S. Faulkner.

Utilizing Mississippi River diversions for nutrient management in a Louisiana coastal watershed. US Dept. of Agriculture. $694,000. 8/01/02 – 7/31/05. J. Day, E. Reyes, J. Cable, and D. Justic.

RECENT EDUCATIONAL HONORS AND DISTINCTIONS

Received the 2000 Lipsey Award for Outstanding Contributions in Teaching and Professional Achievement

Editorial Board of Scientia Marina and Ecological Engineering

Co-chair, Modeling Subcommittee. Monitoring, Modeling, and Research Committee, Gulf of Mexico Program.

Liaison from the NTRC to the National Academy of Sciences committee reviewing the coastal restoration program for the Mississippi delta.

J. W, Day. Invited Keynote Address. La gestion de los rios y la sostenibilidad de los deltas. Jornadas Cientificas: Del Ebro Al Segura: Planificacion Hidrologica Y Sostenibilidad. Tortosa, Spain. 22-24 March 2002.

Member of the Estuarine Research Federation, Louisiana Academy of Sciences, Society of Wetland Scientists, International Society of Ecological Modeling, Society for Ecological Engineering,

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Rybczyk, J., J. Day, and W. Conner. 2002. The impact of wastewater effluent on accretion and decomposition in a subsiding forested wetland. Wetlands. 22(1): 18-32.

Sutula, M., B. Perez, E. Reyes, D. Childers, S. Davis, J. Day, D. Rudnick, and F. Sklar. In press. Factors affecting spatial and temporal variability in material exchange between the Southeastern Everglades wetlands and Florida Bay (USA). Estuarine Coastal and Shelf Science.

Reyes E., J. F. Martin, J. W. Day, G. P. Kemp, H. Mashriqui. In Press. River forcing at work: watershed modeling of prograding and regressive deltas. Wetlands Ecology and Management.

Davis, S. E., D. L. Childers, J. W. Day, Jr., D. T. Rudnick, and F. H. Sklar. In press. Factors affecting the concentration and flux of materials in two southern Everglades mangrove wetlands. Marine Ecology Progress Series.

Reyes, E., J. F. Martin, M. L. White, J. W. day, G. P. Kemp. Habitat changes in the Mississippi Delta: future scenarios and alternatives. R. Costanza (ed.), Spatial Modeling in Coastal Environments. Island Press. Accepted.

Reyes E., J. F. Martin, M. L. White, J. W. Day, G. P. Kemp. In Press. Habitat changes in the Mississippi Delta: future scenarios and alternatives. Ch. 4. In: R. Costanza and A. Voinov (eds.). Spatially Explicit Landscape Simulation Modeling. Springer-Verlag.

* a complete publication list, including relevant publications before 1999, is available upon request*

EXPERT WITNESS (past 4 years)

Louisiana DOTD vs. Monteleone, et al., 2006-2007

Pontchartrain Levee District vs. Monteleone (case settled spring 2007)

Curriculum Vitae

Gary Paul Shaffer
Department of Biological Sciences
P.O. Box 814
Southeastern Louisiana University
Hammond, LA 70402

Phone: (504) 549-2865
FAX: (504) 549-3851
E-MAIL: shafe@selu.edu
SS#: 561-70-5856

EDUCATION

University of California at Santa Barbara, B.A., Aquatic and Population Biology, June 1979
(G.P.A. 3.89 excluding freshman year)
University of California at Santa Barbara, M.A. Aquatic and Population Biology, June 1982 (G.P.A. 3.88)
Louisiana State University, Ph.D., Major: Marine Sciences (Mathematical Ecology),
Minor: Experimental Statistics, August 1986 (G.P.A. 3.77)

EXPERIENCE

1998- Director, Internet Laboratory of Biological Sciences, Contact Dr. Nick Norton, (504)549-3741.
1994- Director, Project CYPRESS, Systemic Initiatives Program, Contact Faimone Roberts, (504) 922-0690.
1993- Development Advisory Board, Global Wildlife Foundation. Contact Ken Matherne, (504) 624-WILD.
1992- Technical Advisor (Region 1 state university representative), evaluation of proposed projects under Breaux-Johnson Bill, Lake Pontchartrain Basin. Contact Dr. Jenneke Visser, (504) 388-6377.
1990- Associate Professor. Dept. of Biological Sciences, Southeastern Louisiana University. Contact Dr. W. Nick Norton, (504) 549-3741.
1987-90 Chief statistical consultant for 220 scientists at U.S.D.A. Southern Regional Research Center. Contact Dr. John A. Barkate (504) 286-4212.
1987-90 Assistant Professor, Dept. of Experimental Statistics and Coastal Ecology Institute, Louisiana State University. Contact Dr. J. G. Gosselink (504) 388-6379, or Dr. J. Geaghan (504) 388-8303.
1986-88 Seer Corporation, consulting, research and development of K-systems analysis software. Contact Dr. Bush Jones (504) 388-2191.
1986-88 Environmental Consultant, Pyburn and Odom. Contact Tim Tate (504) 766-6330.
1986 Post-doctoral Researcher, Coastal Ecology Institute. Contact Dr. J. G. Gosselink (504) 388-6379.
1985-86 Design of knowledge base for Expert System on Multivariate Statistics ("A Guide for Use in Statistical Technique Optimization" - GUSTO). Contact Dr. James Geaghan (504) 388-8303.
1977-82 Head of primary production study of aquatic macrophytes and microflora for California Wetlands Management Project. Contact Dr. Christopher P. Onuf (512) 888-3371.

AWARDS AND HONORS

Best Paper Award at the joint conference of the World Organization of Systems and Cyberntics and the International Institute of General Systems Studies. 2002
President's Award for Excellence in Research, 1996. SLU's annual career award for research productivity.
Faculty Research Award, presented for outstanding scientific manuscript at the annual meeting of the Association of Southeastern Biologists (ASB), 1993. Encompasses twelve states.
Named "Lead Ecologist" of Louisiana by the Ecological Society of America (>9,000 members) for their Ecology in Education Program, 1992.
Faculty Research Award, Association of Southeastern Biologists (ASB), 1988.
Full Member of Sigma Xi, 1987.
Graduate Student Awards: Joseph Lipsey, Sr. Memorial Scholarship, 1986; Eugene P. Odum Award, 1986; First Place Paper, Gulf Estuarine Research Society, 1986; Co-president Marine Environmental Researchers, 1983-84; Louisiana State Rockefeller Scholarship, 1983-1986; Alumni Federation Fellowship, LSU, 1982-1986; Sea Grant Fellowship, UCSB, 1980-1982.

PUBLICATIONS (Refereed Journals, Book Chapters)

Onuf, C. P., M. L. Quammen, **G. P. Shaffer**, C. H. Peterson, J. W. Chapman, J. Cermak, and R. W.Holmes. 1978. An analysis of the values of central and southern California coastal wetlands. In: Wetland Functions and Values: the State of Our Understanding, Eds. P. E. Greeson, J. R. Clark, and J. E. Clark. Amer. Water Res. Assoc., Minneapolis. 186-199.

Shaffer, G. P., and C. P. Onuf. 1983. An analysis of factors influencing the primary production of the benthic microflora in a southern California lagoon. Neth. J. Sea Res. 17(1):126-144.

Shaffer, G. P. 1984. The effect of sedimentation on the primary production of the benthic microflora. Estuaries. 7(4B):497-500.

Shaffer, G. P., and C. P. Onuf. 1985. Reducing the error in estimating annual production of benthic microflora: hourly to monthly rates, patchiness in space and time. Mar. Ecol. Prog. Ser. 26:221-231.

Shaffer, G. P., and P. Cahoon. 1987. Extracting information from ecological data containing high spatial and temporal variability. Int. J. Gen. Sys. 13:107-123.

Shaffer, G. P. 1988. K-systems analysis for determining the factors influencing benthic microfloral production in a Louisiana estuary, USA. Mar. Ecol. Prog. Ser. 43:43-54.

Shaffer, G. P. 1988. A comparison of benthic microfloral production on the west and gulf coasts of the United States: an introduction to the dynamic K-systems model. Mar. Ecol. Prog. Ser . 43:55-62.

Shaffer, G. P., and M. J. Sullivan. 1988. Water column productivity attributable to displaced benthic diatoms in well-mixed shallow estuaries J . Phycology. 24:132-140.

Delucca, A. J., **G. P. Shaffer**, and R. J. Berni. 1988. Analysis of epiphytic bacteria and endotoxin during cotton plant maturation. Am. Ind. Hyg. Assoc. J. 49:539-545.

Delucca, A. J., and **G. P. Shaffer**. 1989. A two year study of the factors influencing endotoxin levels on cotton grown in hot, humid, environments. British J. Indust. Med. 46:887-891.

Marshall, H. F., **G. P. Shaffer**, and E. J. Conkerton. 1989. An improved method for the measurement of free amino acids in peanut (Arachis hypogaea). Analytical Biochemistry. 189:2529-2534.

Ross, L. F., and **G. P. Shaffer**. 1989. The fermentation of carbohydrates by intestinal microflora from infants under aerobic and anaerobic conditions. J. Clin. Micro. 2529-2534.

Gosselink, J. G., **G. P. Shaffer**, L. C. Lee, D. M. Burdick, D. Childers, W. Conner, D. Cushman, S. Fields, S. Hamilton, M. Koch, N. Leibowitz, and J. Visser. 1990. Landscape conservation in a forested wetland watershed: can we manage cumulative impacts? BioScience 40:588-600.

Pitt, J. I., M. A. Klich, **G. P. Shaffer**, R. H. Cruickshank, J. C. Frisvad, E. G. Mullaney, A. H. S.Onions, R. A. Samson, and A. P. Williams. 1990. Differentiation of Penicellium glabrum from Penicellium spinulosum and other closely related species: an integrated taxonomic approach. System. Appl. Microbiol. 13:304-309.

Sasser, C. E., J. G. Gosselink, and **G. P. Shaffer**. 1991. Distribution of nitrogen and phosphorus in a Louisiana freshwater floating marsh. Aquatic Bot. 41:317-331.

Shaffer, G. P., D. M. Burdick, J. G. Gosselink, and L. C. Lee. 1992. A cumulative impact management plan for a forested wetland watershed in the Mississippi River Floodplain. Wetlands. Ecol. Manag.1(3):199-210.

Spanier, A.M., A.J. St. Angelo, and **G.P. Shaffer**. 1992. The response of beef flavor to oxygen depletion and a mixed antioxidant/chelator cocktail. J. Agric. Food Chem. 40(9):1656-1662.

Shaffer, G. P., C. E. Sasser, J. G. Gosselink, and M. Rejmanek. 1992. Vegetation dynamics in the emerging Atchafalaya Delta, Louisiana, USA. J. Ecology 80:677-687.

Bett, K., **G. P. Shaffer**, J.R. Vercellotti, T.H. Sanders, and P.D. Blankenship. 1993. Reducing the noise contained in descriptive sensory data. J. Sensory Studies 8:13-29.

Llewellyn, D. W., and **G. P. Shaffer**. 1993. Marsh restoration in the presence of intense herbivory: the role of Justicia lanceolata. Wetlands 13(3):176-184.

Myers, R. S, **G. P. Shaffer**, and D. W. Llewellyn. 1995. Baldcypress restoration in southeast Louisiana: the relative effects of herbivory, flooding, competition, and macronutrients. Wetlands 15(2):141-148.

Llewellyn, D. L., **Shaffer, G. P.**, N. J. Craig, D. Pashley, L.A. Creasman, and M. Swain. 1996. Restoration of the Mississippi River Alluvial Plain: a decision support system for prioritizing restoration sites. Conservation Biology 10(5):1446-1455.

Shaffer, G. P. 1997. K-systems analysis: an anti silver-bullet approach to ecosystems modeling. IIGSS. 32-39

Day, J.W. Jr. **G.P. Shaffer**, D. Britsch, D. Reed, S. Hawes, and D. Cahoon. 1999. Statistical version of Pattern and process of land loss in the Louisiana coastal zone: an analysis of spatial and temporal patterns of wetlands habitat change (published with permission of Estuaries and written by shafe). In: Recent research in coastal Louisiana: Natural system function and response to human influence. L.L. Rozas, J.A. Nyman, C. E. Proffitt, N.N. Rabalais, D.J. Reed, and R.E Turner (editors). Louisiana Sea Grant College Program, Baton Rouge, LA. p. 193-200.

Keddy, P.A. and **G.P. Shaffer**. 2000. Review of Status and Trends of the Nation's Biological Resources. (M.J. Mac, P.A. Opler, C.E. Puckett-Haecker, and P.D. Doran (eds.), 1998, U. S. Geological Survey, Department of the Interior.) Wetlands 20: 565-566.

Day, J.W., Jr., **G.P. Shaffer**, D. Britsch, D. Reed, S. Hawes, and D. Cahoon. 2000. Pattern and process of land loss in the Louisiana coastal zone: an analysis of spatial and temporal patterns of wetlands habitat change. Estuaries 23(4):425-438.

Dowty, R. A., **G.P. Shaffer**, M.W. Hester, G.W. Childers, F. M. Campo, and M.C. Greene. 2001. The phytoremediation of small-scale oil spills in fresh marsh environments: a mesocosm approach. Marine Environmental Research 52:195-211.

Souther, R.F., and **G.P. Shaffer**. 2000. The effects of submergence and light on two age classes of baldcypress (Taxodium distichum (L.) Richard) seedlings. Wetlands 20: 697-706.

Day, J.W., Jr., **G.P. Shaffer**, D. Britsch, D. Reed, S. Hawes, and D. Cahoon. 2001. Patterns and processes of land loss in coastal Louisiana are complex: a reply to Turner 2001. Estimating the indirect effects of hydrologic change on wetland loss: if the Earth is curved, then how would we know it?. Estuaries 24(4): 647-651.

Thomson, D.T., **G.P. Shaffer**, and J. A. McCorquodale. 2002. A potential interaction between sea-level rise and global warming: implications for coastal stability on the Mississippi River Deltaic Plain. Global Planetary Change 32:49-59.

Hoeppner, S.S., and **G.P Shaffer**. 2004. The K-systems glitch: granulation of predictor variables. Kybernetes: The International Journal of Systems and Cybernetics 33:962-972.

Visser, J. M., G. D. Steyer, **G. P. Shaffer**, S. S. Hoeppner, M. W. Hester, E. Reyes, P. A. Keddy I. A. Mendelsshon, C. H. Sasser, and C. Swarzenski. 2004. Habitat switching module. In: LCA Study – Main Report (Edited by Robert Twilley). US Army Corps of Engineers. New Orleans, LA.

Martin, S. B. and **G. P Shaffer**. 2005. Sagittaria biomass partitioning relative to salinity, hydrologica regime, and substrate type: implications for plant distribution patterns in coastal Louisiana, USA. Journal of Coastal Research 21(1):164-171.

Willis, J.M., M.W. Hester, and **G.P. Shaffer**. 2005. A mesocosm evaluation of processed drill cuttings for wetland restoration and creation. Ecological Engineering 25: 41-50.

Shaffer, G. P., S. S. Hoeppner, and J. G. Gosselink. 2005. The Mississippi River alluvial plain: characteriztion, degradation, and restoration. In: The World's Largest Wetlands. (Edited by L. H. Fraser and P. A. Keddy. Cambridge University Press. Pages 272-315.

Day, J.W., W.H. Conner, and **G.P. Shaffer**. 2006. The importance of pulsed physical events for sustainability of Louisana coastal forested wetlands. In: Hydrology and Management of Forested Wetlands Proceedings of the international Conference. American Society of Agricultural and Biological Engineers, St. Joseph, MI. Pages 158-166.

Keim, R.F., J.L. Chambers, M.S. Hughs, L.D. Dimov, W.H. Conner, **G.P. Shaffer**, E.S. Gardiner, and J.W. Day. (2006). Long-term success of stump sprouts in high-graded baldcypress-water tupelo swamps in the Mississippi Delta. Forest Ecology and Management 234:24-33.

Keim, R.F., J.L. Chambers, M.S. Hughes, J.A. Nyman, C.A. Miller, J.B. Amos, W.H. Conner, J.W. Day Jr., S.P. Faulkner, E.S. Gardiner, S.L. King, K.W. McLeod, and **G.P. Shaffer**. 2006. Ecological consequences of changing hydrological conditions in wetland forests of coastal Louisiana. P. 383-395 in: Coastal Environment and Water Quality, Y.J. Xu and V.P. Singh, eds. Challenges in Coastal Hydrology and Water Quality, Water Resource Publications, Highlands Ranch, Colo. 534 p.

Effler, R. S., **G.P. Shaffer**, S.S. Hoeppner, and R.A. Goyer. 2007. Ecology of the Maurepas Swamp: Effects of Salinity, Nutrients, and Insect Defoliation. In: Tidally Influenced Forested Wetlands, Eds. W.H. Conner, K.W. Kraus, and T.W. Doyle. Springer.

Faulkner, S.P., J.L. Chambers, W.H. Conner, R.F. Keim, J.W. Day, E.S. Gardiner, M.S. Hughs, , S.L. King, K.W. McLeod, C.A. Miller, J.A. Nyman, and **G.P. Shaffer**. 2007. Conservation and use of coastal wetland forests in Louisiana. In: Tidally Influenced Forested Wetlands, Edited by W.H. Conner and K.W. Kraus, and T.W. Doyle. Springer.

Keddy, P.A., D. Campbell, T. McFalls, **G.P. Shaffer**, R. Moreau, C. Dranguet, and R. Heleniak. 2007. The Wetlands of lakes Pontchartrain and Maurepas: origins, processes, and restoration. Environmental Reviews. 15:43-77.

Shaffer, G.P., Wood, W.B, Hoeppner, S.S, Perkins, T.E, Zoller, J.A, and Kandalepas, D. 2007. Degradation of Baldcypress – Water Tupelo Swamp to Marsh and Open Water in Southeastern Louisiana, USA: An Irreversible Trajectory? Journal of Coastal Research. In press.

Shaffer, G.P. and J. W. Day, Jr. 2007. Use of Freshwater Resources to Restore Baldcypress – Water Tupelo Swamps in the Upper Lake Pontchartrain Basin. White Paper. Louisiana Department of Wildlife and Fisheries.

TECHNICAL REPORTS, PROCEEDINGS (Twenty 28, available on request)

PRESENTATIONS

Invited presentations at: Gulf Coast Research Laboratory, Loyola University, Louisiana State University, University of Maryland, Mississippi State University, University of Rhode Island, Washington State University, National Wetlands Research Center, U.S. Corps. of Engineers, US Environmental Protection Agency, American Water Resources Association, LaCEPT, and conferences of the Ecological Society of America, the Estuarine Research Federation, the International Institute for System Studies, the Operations Research Society of America, Sigma Xi, the Association of Southeastern Biologists, the Society of Wetland Scientists, the World Organization of Systems and Cybernetics, and INTECOL. Present 2 to 4 papers per year at regional, national, and international conferences of the following societies: American Institute of Biological Sciences; Association of Southeastern Biologists; Ecological Society of America; Estuarine Research Federation; Gulf Estuarine Research Society; International Association for Landscape Ecology; Society of Wetland Scientists; Coastal and Estuarine Habitat restoration; World Organization of Systems and Cybernetics.

GRANTS AND CONTRACTS (*not* including University match)

Shaffer, G. P. 1987-1990. Statistical consulting. USDA, Southern Regional Research Center. $63,950.

Gosselink, J. G., **G. P. Shaffer**, and C. E. Sasser. 1990. Role of Herbivory in Controlling Plant Succession in an Emerging Coastal Delta. Sea Grant Project R/MPE-48/PD. $22,859.

Shaffer, G. P., and D. W. Llewellyn. 1991. A Landscape Restoration Plan for the Bottomland Hardwood Forests of the Lower Mississippi River Valley, U.S.A. The Louisiana Nature Conservancy. $62,558.

Shaffer, G. P. 1991. The Role of Nutria in Controlling Freshmarsh Vegetation Associations and the Potential for Utilizing Herbivore-resistant Vegetation in Marsh Restoration Efforts. Sea Grant Project R/MPE-61-PD. $13,660.

Shaffer, G. P. 1991-1998. **Fifteen** grants on cypress and marsh restoration. Southeastern Louisiana University Faculty Development Grant. $30,000.

Shaffer, G. P. 1992. Endotoxin in Cotton: A Multivariate Statistical Analysis. USDA. $3,500.

Shaffer, G. P. 1992-95. A Hierarchical Approach to Cypress and Marsh Restoration in the Manchac/Maurepas area: From Landscape Planning to Consideration of Local Herbivores. LEQSF Research and Development Program. $94,904.

Shaffer, G. P. 1993. Statistical and Ecological Consulting. USACE. $1,800. Lee Wilson & Assoc. $2,624.

Shaffer, G. P. 1993. Restoration of the "Prairie" in the Manchac Wildlife Management Area: Creation of Floating Marsh. Orr Memorial Research Grant.

Llewellyn, D. W., and **G. P. Shaffer**. 1994-95. Analyzing Global Change Through Dendrochronolgy Using Remote Sensing Techniques. U.S. Forest Service. $26,098.

Childers, G. W., Bancroft, K., and **G. P. Shaffer**. 1994-96. Bioremediation Protocol for Small-Scale Oil Spills in Louisiana Wetlands. OSRADP. $75,000.

Shaffer, G. P., and G. Purdy. 1994-95. Wetlands Creation for Science Education and Endangered Species Habitat at the Global Wildlife Center: Critical Manipulation of Water Levels. $4,837.

Shaffer, G. P. 1995-96. Discovering Science: An Experimental Arena for the Students of Southeastern. SLU Enhancement Funds. $25,000.

Shaffer, G. P., and Diana Hastings. 1996. Exploring Wetland and Estuarine Micro-Ecosystems in the Classroom: A Technique for Improving Science-Fair Projects. SLU Teacher/Researcher Prg. $2,000.

Llewellyn, D. W. and **G. P. Shaffer**. 1995-96. Adventitious root development, carbon dioxide enrichment, and natural regeneration of *Taxodium distichum* (baldcypress). U.S. Forest Service. $10,000.

Shaffer, G. P. 1995-96. Statistical and Ecological Consulting. LUMCON for CWPPRA. $6,500.

Shaffer, G. P. 1996-97. Statistical and Ecological Consulting. LUMCON for CWPPRA. $4,300.

Shaffer, G. P., M. W. Hester, and G. W. Childers. 1996-97. Use of Restored Drilled Cuttings for Marsh Creation: A Mesocosm Approach. Department of Energy (DOE). $50,000.

Shaffer, G. P., M. W. Hester, and G. W. Childers. 1997. Restored Drilled Cuttings for Marsh Creation: Extension and Expansion of a Mesocosm Approach to Emulate Field Conditions Under Varying Hydrologic Regimes. DOE. $24,998.

Shaffer, G. P., M. C. Greene, and M. White. 1997. A PerPetual Learning Environment (APPLE) for the Department of Biological Sciences at Southeastern Louisiana University. LEQSF. $51,000.

Clausen, S., **Shaffer, G. P.,** Childers, G. W., and R. Moffett. 1997. The Edward G. Schlieder Endowed Chair

of Environmental Studies. Edward G. Schlieder Foundation and LEQSF matching funds. $1,000,000.

Shaffer, G. P. and M. W. Hester. 1997-1998. Coast 2050 Consulting Team. LADNR. $30,620.

Shaffer, **G. P**., M. Hester, and G. W. Childers. 1998-2000. Use of Restored Drilled Cuttings for Marsh Creation: A Field Demonstration Study. DOE. $225,567.

Shaffer, G. P., and E. Simoneaux 1994-2001. Project CYPRESS: Using Wetlands Ecology as a Vehicle for Teaching Mathematics and Science in Louisiana. **Funded 7 times**. NSF (LaSIP). $1,153,000.

Shaffer, G. P. 1998-99. Regeneration of Baldcypress (Taxodium distichum (L.) Richard) Clearcuts and the effects of Submergence, Salinity Pulses, and Light Regime on Various Age Classes of Baldcypress Seedlings. US Forest Service. $11,600.

Souther, R. F., and **Shaffer, G. P.** 1998. Submergence Restrictions on Baldcypress Seedlings. OSCAR. $1,500.

Siccard, R., and **Shaffer, G. P.** 1998. Competition between Three Sagittarias Under Variable Levels of Flooding, Salinity, and Substrate Type. OSCAR. $1,500.

Shaffer, G. P. 1998-99. Statistical and Ecological Consulting for CWPPRA. LUMCON. $9,692.

Martin, G, G., and **G.P. Shaffer**. 1999-2000. Mitigation of 180 acres of balcypress swamp at Sawgrass Bayou and in the Lake Maurepas Basin. Wilprise Pipeline Co. $450,000.

Shaffer, G. P. 1999-2,000. Statistical and Ecological Consulting for CWPPRA: Science Advisor for Complex Projects. CWPPRA. $9,392.

Hester, M., and **G.P. Shaffer**. 1999-2000Analytical Assessment of Novel Substrates for Marsh Creation. Argonne National Laboratory. $43,000.

Shaffer, G.P., M.W. Hester, W.H. Conner, and P.A. Keddy. 2000. A Feasibility Study for a Freshwater Diversion into the Maurepas swamps. LUMCON (EPA, project sponsor). $127,000.

Keddy, P. A., M.W. Hester, **G. P. Shaffer**, W. Font, A. Cheek, P. Stouffer, R. Hastings, R, Moreau, D. Dardis, and W. Norton. 2001. Ecology and Restoration Potential of the Manchac Wetlands. EPA. $186,117 (Shaffer)

Keddy, P. A., M.W. Hester, **G. P. Shaffer**, G. W. Childers, G. Howard, B. Crother, and W. Norton. 2001. Ecology and Restoration Potential of the Manchac Area Wetlands, Phase II. EPA. $134,000 (Shaffer)

Shaffer, G.P. 2001. A Feasibility Study for a Freshwater Diversion into the Maurepas Swamps: Phase 0. LUMCON (EPA, project sponsor, CWPPRA funded). $56,000.

Hoeppner, S. S., and **G.P. Shaffer**. 2001. Lake Maurepas Freshwater Diversion Feasibility Study. EPA STAR Fellowship, $28,586.

Shaffer, G.P. and S.S. Hoeppner. 2001. A Feasibility Study for a Diversion into the Maurepas Swamps: Interim Study Period, April-December, 2001. EPA, $93,751.

Shaffer, G.P. and S. L. Howell. 2001. Studying Noctural Behavior Through the Use of Infra Red Photographic Technology. Student Technology Fee. $2,992.

Shaffer, G.P. and S.S. Hoeppner. 2002-03. Phase 1 Feasibility Study for a Diversion into the Maurepas Swamps. EPA, $108,075.

Shaffer, G.P. 2001-2002. Adaptive Management Team Statistical Consultant. DNR. $25,000.

Shaffer, G.P. 2002-2003. CWPPRA Science Advisor. LUMCON $13,600.

Shaffer, G.P. 2003-2005. Consultant and model builder for the LCA document. ULL and DNR. $28,852.

Shaffer, G.P. 2003. Expert Swamp Ecologist for Barataria Diversion. EPA. $11,436.

Shaffer, G.P. and T. Perkins. 2003. Technological Upgrade for the Wetlands Restoration Laboratory. SLU Student Technology Fee Large Projects Grant. $12, 277.

Shaffer, G.P. and J. Day 2003. Monitoring, Experimentation, and Modeling Environmental Stressors in the Swamps of Lake Maurepas. CREST. $54,742.

Shaffer, G.P. and P.A. Keddy. 2003. Habitat-State Change in the Wetlands of Lake Pontchartrain Basin: From Species Associations to Ecosystem Responses Under Different Diversion Scenarios. LPBRA, NOAA. $159,777.

Shaffer, G.P. 2003. A Whole-System Approach for Restoring the Wetlands of the Western Lake Pontchartrain Basin. EPA. $340,000.

Shaffer, G.P. 2004-. Ecological Consultant – CWPPRA Monitoring Program. DNR. $22,800.

Shaffer, G.P. and P.A. Keddy. 2004-2006. Habitat-State Change in the Wetlands of Lake Pontchartrain Basin: From Species Associations to Ecosystem Responses Under Different Diversion Scenarios. LPBRA,NOAA. $136,318.

Shaffer, G.P. 2006-2008. De-energizing Storms with Cypress/Tupelo Buffers: A Plan to Restore the Repressed Swamps of the Lake Pontchartrain Basin by Using Point and Nonpoint Sources of Freshwater. EPA (PBRP). $148,600.

Shaffer, G.P. 2006-2007. Habitat State Change and the Effects of Hurricanes Katrina and Rita on Aboveground

Turnover in the Manchac/Maurepas Wetlands Under Varying Restoration Scenarios. CREST $74,830.

Shaffer, G.P. 2006-2007. Reducing Hurricane-Damage in the Lake Pontchartrain Basin by Using Point Sources of Freshwater to Regenerate Cypress – Tupelo Swamps: A Demonstration Project. NOAA (PRP). $122,365.

Shaffer, G.P. 2007-2008. Restoring Baldcypress – Water Tupelo Swamps in Assimilation Wetlands and Locating Other Potential Sites by Creating the Basin-Wide Swamp Sustainability Map. $118,704.

TEACHING EXPERIENCE

Applied Biostatistics (undergraduate-graduate level (UG)); Botany (U); Biological Science for Teachers (G), Ecology (U); Ecological Methods (U); Estuarine Ecology (G); Experimental Design (G); Experimental Design for Teachers (G); Experimental Statistics for Agricultural Sciences - I, II (G); Foundations of Biology (U); Multivariate Statistics (G); Plant Ecology (UG); Simulation Modeling (UG); Statistical Techniques for Environmental Sciences - I, II (G); Science for Teachers (G); Wetlands Ecology (UG).

OTHER TEACHING INTERESTS

SAS Programming I, II; Geographic Information Systems; Landscape Ecology; Aquatic Ecology; Phycology.

REVIEWER

American Journal of Botany, Diatom Research, Estuaries, Journal of Experimental Botany, Journal of Experimental Marine Biology and Ecology, JGR Oceans, Journal of Phycology, Marine Ecology - Progress Series, WETLANDS, Mississippi-Alabama Sea Grant proposals, National Wetlands Research Center, National Oceanic and Atmospheric Administration proposal, Louisiana Agricultural Experiment Station proposals, many peer reviews for colleagues.

EXPERT WITNESS (past 4 years)

Louisiana DOTD vs. Monteleone, et al., 2006-2007

Pontchartrain Levee District vs. Monteleone (case settled spring 2007)

Appendix I

MRGO-PHOTOS 57, 71, 109, 127, 133, 141, 163, 266







19 JAN 1959 U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS NO. 9850-10

MISSISSIPPI RIVER - GULF OUTLET

Dredging Mississippi River-Gulf Outlet 36' x 500' channel from Station 0+00 to Station 130+00. Under Contract No. DA-16-047-CIVENG-58-408 with Jahncke Service, Inc., New Orleans, La., dated 12 March 1958.

Dredging Bayou Bienvenue opposite approximately Station 160+00 on main channel.

MRGO-PHOTOS-0000109



9 JULY 1958

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS

NO. 9773-13

MISSISSIPPI RIVER - GULF OUTLET

Dredging Mississippi River-Gulf Outlet 36' x 500' channel from Station 0+00 to Station 130+00. Under Contract No. DA-16-047-CIVENG-58-408 with Jahncke Service, Inc., New Orleans, La., dated 12 March 1958.

Dredging in Bayou Bienvenue opposite vicinity Station 115+00 on main channel under construction.

MRGO-PHOTOS-0000127



9 JULY 1958

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS

NO. 9773-10

MISSISSIPPI RIVER - GULF OUTLET

Dredging Mississippi River-Gulf Outlet 36' x 500' channel from Station 0+00 to Station 130+00. Under Contract No. DA-16-047-CIVENG-58-408 with Jahncke Service, Inc., New Orleans, La., dated 12 March 1958.

View east vicinity Station 110+00. GIWW at right.

MRGO-PHOTOS-0000133



9 JULY 1958 U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS NO. 9773-6

MISSISSIPPI RIVER - GULF OUTLET

Dredging Mississippi River-Gulf Outlet 36' x 500' channel from Station 0+00 to Station 130+00. Under Contract No. DA-16-047-CIVENG-58-408 with Jahncke Service, Inc., New Orleans, La., dated 12 March 1958.

View east vicinity Station 26+00. Dredge working in upper center. Spoil area for Item No. 1 at right.

MRGO-PHOTOS-0000141

MRGO-PHOTOS-0000163



24 JUNE 1958

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS

NO. 9771-10

MISSISSIPPI RIVER - GULF OUTLET

Dredging Mississippi River-Gulf Outlet 36' x 500' channel from Station 0+00 to Station 130+00. Under contract No. DA-16-047-CIVENG-58-408 with Jahncke Service, Inc., New Orleans, La., dated 12 March 1958.

Dredge PAUL F. JAHNCKE working vicinity Station 26+00.



MRGO-PHOTOS-0000266