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Contesting the Coast:

Ecosystems as Infrastructure in the Mississippi River Delta

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Abstract

We develop an analytical repertoire for understanding historical interrelationships between water infrastructure, regional environmental politics, and large-scale coastal ecosystems. In doing so, we scrutinize how notions of urban resilience, climate adaptation, and ecosystem-based infrastructure are influencing contemporary planning practice. Our account from New Orleans and the Mississippi River Delta traces several large-scale hydrological engineering projects with origins in the early 20th century, which aimed to restructure the landscape for more effective maritime transportation, flood protection, and urban drainage. The account concludes with a discussion of a massive and ongoing planning project, which aims to restore the historical dynamics of the Mississippi River Delta, diverting the river into nearby coastal wetlands to provide storm protection for vulnerable communities, most especially New Orleans. Our analysis shows how the development of water infrastructure systems in the region produced cleavages in the region's body politic and eco-hydrology, generating disputes that threaten to slow or obstruct the plan's implementation. The study shows how the forms and discourses of political contention in the present are deeply informed by past decisions regarding the placement, operation, and maintenance of large-scale water infrastructures in the region. The conflicts that emerge from these cleavages comprise the primary obstacle facing ecosystem-based strategies aimed at securing New Orleans and other major settlements in the region from storm surges. This raises fundamental challenges for planning practice, which are explored here through a discussion of situational dissensus, conflicting rationalities, and pathways for democratic institutional innovation.

Keywords: New Orleans; Deltaic landscapes; Environmental politics; Urban ecology; Expertise.

Research Highlights:

- › The benefits of ecosystem-based infrastructure planning along urban coasts are becoming widely embraced by powerful social actors in the face of climate impacts.
- › The establishment of infrastructural zones and standardized interventions transforms social and ecological relations, and structures the trajectory of politics and environmental change over decades, perhaps even centuries
- › The concept of socioecological cleavages can provide lessons for planning theory in light of historical injustices at the urban-rural interface.
- › Ecosystem-based resilience strategies necessarily become entangled with land rights, sense of place, and community displacement.

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1. Introduction

Over the past decade, scholars and policymakers have focused on coastal cities as the frontline for the impacts of rising seas and coastal storms (Hallegatte et al., 2013). Sea level rise projections have steadily increased over the same period, with current estimates suggesting that a minimum one-meter rise in sea level will likely occur during the 21st century (Giosan 2014; Pachauri et al., 2014). Concurrently, research on cities has grown considerably, as report after report heralds the arrival of the “Anthropocene,” the “urbanization of humanity,” and “planetary urbanization” as more people move to cities and human activity acts as a powerful driver of atmospheric and geological processes (Crutzen 2006; Steffan et al., 2011; Brenner and Schmid 2011). Thus a particular intersection of large-scale trends in human population, global sea level, and political discourse is occurring: Firstly, humanity is increasingly urban and coastal. Secondly, that same coastal terrain and population is increasingly vulnerable to extreme events. Third, noted scientists have declared a new ecological and political reality that acknowledges human influence over planetary-scale processes, a moment some have described metaphorically as the nailing of a “golden spike,” which marks the passing of one geological epoch to the next.¹ As this term suggests, various forms of infrastructure are at the root of the human re-shaping and dominance of the landscape, especially so in urban regions, and especially along coastlines where water is both a vital asset and a dynamic natural force.

Meanwhile, a new conceptual language is beginning to permeate research and planning initiatives along urbanized coasts – *adaptation, ecosystem-based, resilience, emergence, uncertainty*. These terms reflect the broader move in the environmental and social sciences towards complex systems-oriented approaches that stress non-linear change, scalar relationships, and linked social-ecological processes (Adger et al., 2005; Folke, 2006; Ernstson et al., 2010). This represents a turn from approaches that have typically emphasized engineering, equilibrium, and command and control (Holling and Meffe 1996). For example, emerging approaches to water planning for coastal cities emphasize blending traditional water infrastructure with “ecosystem-based” strategies that strives to mobilize the ‘natural’ capacities of coastal ecosystems to mitigate the impacts of sea-level rise and coastal flooding. Reading across the coastal ecosystems initiatives of The Netherlands, UK, New York and Louisiana, a common feature is that they draw upon “resilience thinking” (Folke et al. 2005). This follows a more general policy trend (Evans, 2011), where resilience works as a master narrative to organize other scientific information in order to describe the urgent need for coastal cities to invest in adaptive capacity, ecological restoration and environmental management to enhance their capacity to recover and live with

¹ Interesting for our purposes is that the original usage of the term “golden spike” has an origin in the construction of large-scale infrastructure. A golden spike was used to ceremonially commemorate the completion of the transcontinental railway across the US frontier in 1869. The railroad and the golden spike signified Anglo-American dominance of the continent’s landscapes and peoples. Thanks to Ashley Carse for pointing out this parallel.

climate-driven uncertainty. Large private and state funds have brought together 'ecosystem-based infrastructure' with 'resiliency' expertise. Beginning in 2013, the Rockefeller Foundation's "100 Resilient Cities" initiative has worked to embed resilience discourse in urban governance in cities worldwide. A partnership between the US Department of Housing and Urban Development (HUD) and the Rockefeller Foundation recently provided \$1 billion to US communities to develop resilience strategies. In describing their partnership with HUD, Rockefeller's president claimed that "[b]uilding resilience will minimize the impact of the next shock, while also improving life in communities day-to-day, allowing them to yield a resilience dividend. Everyone wins."² But suggestions that "everyone wins" in the implementation of large-scale infrastructure projects, "ecological" or otherwise, neglects the deep historical divisions, stubborn infrastructural embeddedness, ecological surprises, and territorial conflicts that permeate these initiatives.

Where state agencies and philanthropists see "urban resilience" strategies with inclusive benefits, Hodson and Marvin (2010) view these developments as a push for "urban ecological security." They describe a move in urban governance towards policies they characterize as "secure urbanism and resilient infrastructure," and suggest that urban resilience can be seen as an increasingly elite-driven governance strategy in which infrastructure and ecosystems are aligned with strategies of capital accumulation. This observation gives rise to concerns that urban resilience, if enacted narrowly as an accumulation strategy and spatially exclusionary planning tool, could in fact reproduce and entrench economic inequality and produce "new peripheries constructed by enclosure" (p. 210). This perspective resonates with the work of Adger (2003; 2005) and Nelson et al. (2007) who warn that "many present strategies for adaptation reduce the vulnerability of those most able to mobilize collective action and those with greatest access to decision making. Most adaptation, in other words, does not necessarily reduce the vulnerability of those most at risk." This paper uses historical analysis to examine the roots of these contradictions in coastal Louisiana. More specifically the article traces the historical transformation of an estuary on the periphery of New Orleans, Louisiana along the US Gulf Coast. In parallel we use this case study to develop an alternative theoretical framework to understand the predicament of coastal urban regions in the wake of large-scale biophysical changes.

Urbanized coasts and deltas like those found in Louisiana are economically and ecologically dynamic spaces, which makes Louisiana an intriguing and valuable case study to gain more general understanding and contribute to a rapidly growing literature. With increasing intensity, coastal cities now discuss the impending effects of elevated seas and swollen storm surges, with urban and environmental planners developing ideas around the role of flood protection

² "HUD Launches \$1 Billion National Disaster Resilience Competition" Rockefeller Foundation Press Release. Available from: <http://www.rockefellerfoundation.org/newsroom/hud-launches-1-billion-national>. Accessed December 13, 2014.

infrastructure and coastal ecosystems in buffering storm impacts (Ahern, 2007; McGranahan et al., 2007). The risk is real and not so far into the future. As Seto (2011) estimates, by 2050, global population could grow by 2.7 billion people, mostly in small and medium sized cities in Africa and Asia, with coastal and deltaic cities being a “preferred migration destination over other locations” (Seto 2011: 104). Concurrently, and with direct effect in Louisiana, projections suggest that unprotected coastal terrain less than two meters above sea level could be inundated by 2100 (Giosan, 2014; Pachuari et al., 2014). While many human settlements along coastlines will be forced to retrofit, modernize, or adapt flood protection systems, this is especially true in river deltas, where naturally occurring and human induced soil subsidence and coastal land loss are leaving low-lying settlements dangerously exposed to tidal action and storm surges. A conventional emphasis on structural barriers, levees, and floodgates is increasingly seen by engineers, policymakers, and coastal citizens as only one component of a more holistic approach to coastal resilience, as evidenced across various initiatives: in the Netherlands, with a focus on “living with water;” in the *Louisiana Coastal Master Plan* (CPRA 2007; 2012; 2017); New York City’s 2013 *Special Initiative for Rebuilding and Resiliency*; and recent announcements of a national flood protection strategy in Great Britain (Barbier et al., 2013; Spalding et al., 2014; Wamsley et al., 2010). Retrofitting or adapting existing water infrastructures, or the creation of “hybrid” infrastructures has also been suggested as a way to build and maintain protective wetland buffers around or within cities (Spalding et al., 2014). This literature and related policy initiatives demonstrate that ecosystem-based infrastructure projects are becoming more broadly articulated and adopted to address these challenges – along with an important planning research agenda.

It is possible to appreciate the novelty and utility of hybrid and ecosystem-based infrastructure, while not de-emphasizing the deeply contested character of these coastal land and waterscapes. Our empirical account will show how the externalities of urbanization through the building of infrastructural networks have come to extend into areas beyond the city limits and into ecologically dynamic riverine and estuarine environments, unleashing deep-seated biophysical relations that come back and haunt planners, animating contemporary conflicts. In parallel we will develop an analytical approach for understanding infrastructure, coastal ecosystems, and planning disputes as *historically intertwined*. With this we hope to deepen ongoing discussions around coastal planning, urban resilience, and climate change adaptation.

This is accomplished by historicizing a contemporary political controversy stemming from an ambitious proposal to harness the land building capacity of the Mississippi River to protect New Orleans and coastal Louisiana from storm surges. While the science of re-engineering the Mississippi is oriented towards grappling with the future, the politics of this initiative are very much grounded in the past. At the core of the controversy lies the fact that over the last century the deltaic plain has been cut-off from new sediment inputs and it is rapidly eroding into the Gulf of Mexico (Blum and Roberts, 2009). This land loss places millions

of people and trillions of dollars of infrastructure at heightened risk from hurricane storm surges. The first major infrastructural asset at risk is the Lower Mississippi River port complex, the largest port complex in the western hemisphere by tonnage (AAPA, 2013). Secondly, the oil and gas extraction, conveyance, and refining infrastructure in the region enables over 25% of US oil and gas production. Over 40% of US refining capacity is situated along the region's coastline (Batker et al., 2014). The New Orleans metropolitan area has over a million people that live on the Mississippi River's alluvial plain. The Mississippi River Delta has lost 1,900 square miles (c. 4,900 km²) of land over the past century, with another 700 square miles (c. 1,800 km²) expected to disappear over the next 35 years (Day et al., 2014). A series of intense hurricanes beginning with Katrina in 2005 have accelerated this land loss process, caused billions of dollars in property damage, disrupted global flows of petroleum, coal, and grain, and killed almost 2,000 people in the Mississippi Delta. The 2010 British Petroleum oil disaster in the Gulf of Mexico brought further ecological and economic impacts to the region, particularly for coastal fishing communities (Austin et al., 2014; Sumaila et al., 2012; Upton, 2011). Recently, state officials have even conceded that while major infrastructural interventions and land building projects may slow overall land loss, the Mississippi Delta will shrink substantially over the next century even under a best case scenario for sea level rise and prompt project implementation (CPRA 2017).

With land loss in coastal Louisiana at a critical stage (Figure 1), and the viability of the region's major cities under scrutiny by observers, the State of Louisiana and the US Government are currently developing a long-term plan to re-engineer the delta's hydrology, in part through the re-introduction of freshwater and sediment into the delta's estuaries through the construction of diversion control structures along the banks of the Mississippi River (Figure 2 displays The 2012 Coastal Master plan). The fines and legal settlements associated with the 2010 BP oil disaster are bringing billions of dollars in funding to Louisiana to begin implementing these projects, an unexpected windfall for the initiative. While some features of this plan (dredge and fill, shoreline protection, oyster reef construction) enjoy broad support from the region's residents, the implementation of river diversions has emerged as the major political sticking point. Many coastal scientists and engineers claim that the entire plan to prevent the delta from sinking into oblivion depends chiefly on the construction of large-scale river diversions. As the chairman on the state's Coastal Protection and Restoration Authority (CPRA) recently remarked, "In the next 10 years, we will likely determine the footprint of the state of Louisiana... You've got to take a step back and really look and think big picture: Which areas can be saved and should be saved?" (Jacobs, 2015).

An organized opposition to so-called 'river diversions' has developed as state planners move forward with designs and identify funding mechanisms. Opponents have cast diversions as potentially devastating infrastructural interventions that will ruin productive fisheries, prioritize urban flood protection over that of coastal communities, and actually accelerate, not slow, coastal land

loss. Competing claims on expertise and scientific understanding are also at work, with certain coastal geologists skeptical that river diversions will have any substantial positive impact, while others see diversions as the region's key to survival. With public pressure to 'fix the coast' at an all time high following several catastrophic disasters, newly organized planning authorities within the state of Louisiana have sought to reimagine the Mississippi River Delta as a vast system to be centrally managed through water infrastructure and state institutions. Planners consequently present coastal wetlands built by the Mississippi River as a degraded natural system that must be restored to its historical functionality. This ecological view of the delta is historical in its grasp of the physical development of the delta's land forms, but historical geometries of social power implicated in prior modifications to natural processes are typically left outside discussions around the region's future.

This recognition by state planners that the delta is in rapid decline and that critical infrastructure and major cities are increasingly at risk, has heralded, we mean, a new enthusiasm by elite interests to assert new (and as we will see quite old) forms of territorial governance in the urban periphery. In this journal, Marshall (2014) productively discussed how "spatial imaginaries" of territory are part and parcel of the politics of infrastructure provision, and so-called "big planning." Marshall, drawing upon Massey (2005), points out that any given "spatiality," can be viewed not as an a priori or given territory, but as an emergent geography constructed through uneven geometries of social power and a particular set of spatial or territorial logics and imaginaries. In this regard, New Orleans and the Mississippi Delta present an intriguing environment to scrutinize the advent of "ecosystem-based infrastructure" in the coastal zone, and historicize the existing infrastructures and the uneven socioecological relations that such initiatives strive to transform.

Our case study then contributes a careful tracing of the origins of a contemporary controversy through the establishment of infrastructure projects in the early 20th century. The study shows how the forms and discourses of political contention in the present are deeply informed by past decisions regarding the placement, operation, and maintenance of large-scale water infrastructures in the region. The benefits and hazards associated with these canals, pumps, gates, and levees have been unevenly distributed, and the current opposition to river diversions has emerged within the community impacted most negatively by these initiatives. As we will describe, this historical process can be viewed as one in which the urban center of New Orleans and its associated agglomerations of financial capital, institutional capacity, and political power, has sought to rework its periphery to secure its economic position and enroll peripheral ecologies into the infrastructure of urban drainage, flood protection, and maritime transportation. As sea-level rise projections continue to alarm coastal communities globally, the politics around river diversions in Louisiana reveal important insights into potential impediments and politics of large-scale coastal infrastructure planning.

Through working with this case study, we have come to develop a framework around the core heuristics of *infrastructural zones*, *ecological regimes*, and *socioecological cleavages*. This framework aims to situate the contemporary politics around river diversions within a longer historical and broader geographical context. The account then draws upon archival research, in-depth interviews, focus groups, GIS analysis, and participant observation to account for the development of the adversarial state of affairs surrounding the region's resilience strategies. If New Orleans and the Mississippi River Delta are to endure as population centers into next century, the Mississippi's alluvial plain must undergo profound hydrological and morphological transformations. Just political processes, and just outcomes for those communities most at risk and most impacted by the adaptation of the delta's footprint are critical (though woefully underemphasized) aspects of the coastal restoration initiative at large.

The article proceeds as follows. In the following section we provide an overview of the conceptual framework developed through the article. Section 3 presents the historical account, which shows how infrastructural networks associated with urban drainage, flood protection, and maritime transportation have transformed New Orleans' eastern periphery over the 20th century. Section 4 demonstrates how river diversion infrastructure has been put forward as a way to resolve the ecological contradictions laid bare by the ecological transformations wrought by 20th century water infrastructure, and traces the emergence of opposition to river diversions in neighboring St. Bernard Parish. We conclude in section 5 with a discussion of the theoretical themes of the article and make policy recommendations regarding the planning process for river diversions and coastal resilience planning at large. Section 6 concludes the paper.

2. Theoretical Framework

Grasping socio-political, technological, and ecological processes in tandem, over long time scales, is a complex conceptual undertaking. The theoretical framework developed here attempts to build understanding of contemporary political disputes by elucidating how infrastructure, ecosystems, and politics are historically co-produced. The following section outlines how drainage systems and shipping canals comprise *infrastructural zones* intended to predictably convey various flows of waste, water, and commodities across geographic variation. These zones fragment urban space and generate peripheries while simultaneously facilitating particular forms of global connection. Altering ecological relations through infrastructure can trigger profound environmental transformations we refer to as *ecological regime shifts*. In our case, regime shifts have undermined flood protection systems and altered previous natural resource-based livelihoods to re-structure social interests. Over time, these cascading effects have coalesced into what we view as *socioecological cleavages*, persistent partitions in hydro-ecological systems and human communities with serious political implications in the present. When urban interests—from engineers, town planners to port administrators and environmentalists—seek to reorganize the urban periphery to improve flood protection and cope with

climate change they are met by resistance from groups whose interests have become entangled and shaped by ecological regime shifts. Despite the dire circumstances and rational political arguments for further infrastructural interventions in the periphery, planners and decision-makers are faced by *situational dissensus* – political opposition emerging out of historically place-based dynamics that are difficult to address through deliberative planning and collaborative governance. In the following section we introduce this conceptual sequence in greater detail, before turning to the swamps, infrastructures, and controversies brewing in coastal Louisiana.

2.1. *Infrastructural Zones*

Infrastructural zones are assemblages linked through technical standards, intended to generate “comparable results in disparate domains” (Barry, 2006: 11). Water infrastructure facilitates both place-based environmental transformations and also movement and communication across distance (Carse, 2012, 2014; Carse and Lewis, 2017). This means that the pipes and canals that crisscross the Mississippi Delta are not only from ‘here’, but are made manifest through wider circuits of political patronage, scientific expertise and technical standards from a multitude of ‘elsewheres.’ These are the geographies that emerge as places are simultaneously connected, disconnected, and transformed by urbanization and globalization (Barry, 2006). Our paper examines four such infrastructural zones – clusters of technology and expertise assembled to: 1) drain flood-prone terrain for urbanization; 2) provide structural protection to communities against flooding; 3) facilitate maritime transportation and connect the delta to global trade pathways; and 4) adapt the delta’s hydromorphology to protect human settlements from the conjoined effects of sea level rise and storm surges.

As these infrastructural interventions overlap and become part of ecological relations, they generate path dependencies in ecosystems and shape dynamics of political contention around water resources. This observation undergirds our call to examine infrastructural politics historically. The technical standards and spatial topologies of infrastructural zones are typically fixed within short historical windows wherein scientific experts are called upon by various parties to make claims about the economic impact, engineering assumptions, and environmental risks associated with constructing, modernizing, or scaling them back. In our account we view these windows as critical junctures in the development of the ecological relations, socio-material flows, and patterns of human settlement that comprise cities and their peripheries. Decisions at one juncture can “return” much later (ecosystem collapse, technical failure, political claims of historical injustice), haunting managers and engineers with complex problems decades and in some cases, centuries later. These critical junctures influence the establishment of infrastructural zones that in turn produce environments that shape deltaic settlement patterns and the landscape of risk in the region. Moreover, in a dynamic geophysical setting like the Mississippi River delta, coastal planning policy in the 21st century is circumscribed by earlier enactments of the landscape. Finding a large deposit of sand, or an ancient

cypress stump in the delta's soils can tell you a great deal about how water moved in the landscape in the deep past, which can provide insights into how effective certain restoration or infrastructure strategies might be.

The distinction between 'landscapes' and 'infrastructures' is increasingly blurry, especially along coastlines and waterways. Ashley Carse's analysis of the Panama Canal provides for us an important analysis of how infrastructures that "jostle for territory" to secure infrastructural zones, also "produce environments" (Carse, 2012; Carse 2014:14). The Panama Canal locks place high demands on surface and subsurface freshwater flows in the canal's vicinity as they are needed to continuously re-fill the canal with water to convey global maritime traffic. The surrounding waterscape is thus critical to the canal's basic functionality. This requires the disciplining of the wider landscape—and its residents. While Panama Canal authorities strive to maximize freshwater storage by reforesting the slopes around the waterway, at times this conflicts with local agricultural practices and rural development programs. Due to its centrality in global trade, the technical standards used in the Panama Canal are subsequently applied in distant waterways and ports that seek to participate in the global infrastructural zone anchored by the Panama Canal, which in turn generates further 'local' conflicts in other locations (Carse and Lewis, 2017; Ramos, 2014). The notion of infrastructural zones helps to interpret our empirical material in terms of the territorial, spatial, and environmental aspects of infrastructure projects, how they actively produce landscapes, and how 'local' conflicts are connected across vast geographies (Bowker and Star 1999; Edwards 2010; Star and Ruhleder 1996; Carse 2012; 2014). The Panama Canal example reveals how infrastructural zones enroll territories to facilitate certain forms of mobility and connectivity, while foreclosing upon others.

2.2. *Ecological Regime Shifts*

As a material technology that mediates flow, water infrastructure becomes part of the ecosystems in which it intervenes—and over time, ecosystems might reorganize around the material parameters established by the infrastructure itself.³ When these changes are severe in how ecosystems operate and function, non-equilibrium ecologists have since the end of the 1960s (Lewontin 1969; Holling 1973) theorized these as *ecological regimes shifts*, with a recent rapid proliferation of studies (Lade et al. 2014;; Scheffer & Carpenter 2003; Scheffer et al. 2009; Walker and Meyers 2004). Rocha and colleagues (2015) found that regime shifts are especially common in coastal ecosystems, the "most highly threatened and productive [eco]systems in the world", and identified anthropogenic factors as drivers of regime shifts, including "loss of habitat due

³ We use 'ecological systems' or 'ecosystems' in this paper as shorthand for material and geochemical relations that have become stable and 'systemic' over time, i.e., produced and reproduced through mutually reinforcing relations. While the commonplace use of the word 'ecosystem' often refers to a bounded unit or object with clear conceptual and geographical boundaries, for instance as in "the lake ecosystem", "the coral reef ecosystem", or "the forest ecosystem", we are not making such claims of clear boundaries when using the word.

to urbanization, human population growth, infrastructure development, increasing sewage and pollution, declining water quality and increasing disease risk" (Rocha et al, 2015: 9).

While early studies developed historical understandings of ecological regimes shifts, as in studies of the Florida Everglades (e.g., Scheffer & Carpenter 2003), later studies have relied, sometimes in problematic ways, on reified and simplifying models, alongside a-historical and moral statements of shifts from "desirable" to "degraded" ecological "states."⁴ Here we stress the necessity of an historical (and thus social and political) ecological approach to understand regime shifts and their path-dependencies, which more closely follows original developments of non-equilibrium ecology by Lewontin (1969; cf. Lewontin and Levins 1985). To this we add that the standardization of water infrastructure opens a window to understand historically why a restructuration of socioecological processes occurs over time. Indeed, infrastructure embodies relations to water, sand, and soil to unmake some relations, while producing new ones. Certain water infrastructures also transform relations amongst humans, animals, pathogens, vegetation, the bio- litho- and atmosphere. Infrastructures thus persist, just as technical standards do, over long time periods becoming socially and ecologically embedded. As we will account for, these processes generate unexpected effects that challenge traditional notions of "degradation" and "restoration."

This dynamic is at work in coastal Louisiana. Flood protection systems prevent the Mississippi's freshwater and sediments from replenishing its deltaic plain. Subsequently, coastal land loss has accelerated and marine ecosystems have encroached inland. Perhaps counter intuitively however, deteriorating marshlands happen to be ideal habitat for several commercially important marine species. This new ecological regime, rendered real through infrastructure, has produced lucrative commercial and recreational fisheries, but lacks the capacity to substantially absorb storm surges (Saltus et al., 2012). Once these new ecological trajectories emerged, people and institutions were faced with resource intensive efforts to restore previous ecological regimes (sometimes impossible), invest in adaptation measures that exploit the emergent ecological regime, or take measures to produce an alternate ecological configuration. Over time, new economic, technological, and cultural dependencies have developed around emergent ecological regimes. This has generated political constituencies that are committed to maintaining the new status quo, also observed elsewhere (Holling and Meffe, 1996). What is "degraded," "restored" or "desirable" is an

⁴ Ecological regime shifts signify abrupt changes in ecosystems due to historical and complex interactions among social and ecological factors. The now basic definition states that ecological regime shifts happen when key biophysical variables pass a "critical threshold," for instance through increased nutrients, pollution or salt content in soils or water, followed by a sudden event, say a drought or flooding. This could trigger a reorganization, either into a comparable relational configuration, thus demonstrating ecosystem resilience, or shift into a new ecological regime with different mutually reinforcing structures and processes, referred to as an "alternative stable state." (For more on this, see e.g., Möllmann et al., 2015; Rocha et al., 2015.)

open and frequently contested matter, and controversies over which ecological regimes are appropriate and which 'ecosystem services' should be prioritized are subject to power-laden deliberations and conflicts (Ernstson, 2013), which we will attend to.

Decisions made at critical junctures regarding the territorial scope, hydrological connectivity, and techno-environmental standards of infrastructural zones shape the subsequent development of regional ecological systems. The territorial scope of ecological regime shifts can far exceed the infrastructure's physical footprint, especially when water is involved. A control structure at one bend in a river can shape landscape configurations hundreds of kilometers away. The power of such structures to drive ecological outcomes and organize the landscape in the interest of certain social actors means that these structures carry politics that extend from the homes in the shadow of a floodwall in New Orleans to the global circuits of capital and commodities coursing through the Panama Canal, and beyond.

2.3. *Socioecological Cleavages*

Just as ecological regimes can over time become organized around the standards and materiality of pipes and canals, social processes and local politics can be shaped by the spatial configuration of infrastructure networks and environmental management practices. The political processes involved in achieving ecological projects in the urban periphery are embedded in historical patterns of political power. These relations can exhibit spatial and social cleavages between the urban core and politics in peripheral communities.

Political scientists have explored the tensions between centers and peripheries extensively. The work of Stein Rokkan (Lipset & Rokkan 1967) is exemplary in this case. Rokkan analyzed how centers like cities and national capitals tended to be politically dominant and able to mobilize the architecture of the state to subordinate their peripheries and regions. Peripheries often resist these attempts at subordination and work to frame their interests outside of the dominant logic of the center. The cultural repertoires at the disposal of peripheral communities can appear regressive, quaint, or ignorant by elites in the center, who see the modernization of peripheral territories as important aspects of urban territorial governance (Zarycki 2007). Our case study contributes much more attention to how ecological dynamics—mediated through infrastructure and infrastructural zones—shape social differences and identities across wider landscapes in a development of Massey's (2004: 5) notion that "[i]dentities are forged in and through relations [and] are not rooted or static, but mutable ongoing productions." Taking in these socioecological cleavages and their production of conflicting rationalities poses critical challenges for the implementation of ecosystem-based infrastructures that seek to rework urban peripheries.

The operation and management of large infrastructural systems is a key point of contention in these sorts of center-periphery conflicts along urbanized

coastlines. Indeed, the historical processes of infrastructure provision, and the connections, enclosures, and disconnections this entails, are generative of the ecological discontinuities and political cleavages that mark the landscapes and politics of urban regions. The relations between urban and coastal communities in Louisiana show how contemporary ecosystem-based resilience strategies are faced negotiating across linguistic, cultural, and territorial cleavages that fracture urban regions. These cleavages, wrought through the establishment of infrastructure networks, are generative of complex political controversies that challenge both the analysis of politics and defy the tidy descriptions and prescriptions of systems-based approaches to planning.

2.4. *Situational Dissensus and Knowledge Controversies*

Socioecological cleavages create a real challenge for mainstream planning, which often strives to forge consensus in a situation where deep disagreements prevail. A more productive starting point is to account for, and perhaps make room in planning for, what we refer to as *situational dissensus*, i.e., a place-based situation where social groups express deep disagreements shaped by historical socioenvironmental trajectories.⁵ This situation requires, we mean, alternative modes of analysis and planning.

Empirically we can analyze situational dissensus as knowledge controversies. When large-scale infrastructure intersects with dynamic ecosystems the consequence is that nobody can truly be 'in the know'. This leads to disputes over facts and competency and opens a window to do empirical analysis. We draw upon constructionist and sociomaterialist studies of knowledge claims in contested urban landscapes (Ernstson 2013; Ernstson and Sörlin, 2009, 2013; Erixon Aalto and Ernstson 2017) to account for the articulation of a counter-narrative over how to best intervene in the coastal ecosystems of Louisiana. As the counter-narrative grew from 2010 (with roots going back a century), a knowledge controversy that had existed among established experts around assumptions, costs and risks, was forced out of closed boardrooms and became public. This created an "intense *public* interrogation [over what] we think we know or, more usually, what 'experts' claim to know" (Whatmore, 2009: 587) as a result from the controversy. Our approach, to squarely focus on how dissensus emerges through historical processes (rather than starting from a position of seeking out 'rational interests' or 'stakeholders'), calls into question prevailing planning paradigms. The silver-lining is that while controversies are often viewed negatively, they can be *generative* in undermining regimes of sense-making to redistribute expertise and open for *new forms of knowledge construction* to shape planning (cf. Whatmore 2009). For planning theory, our case study provides openings for rethinking planning in the context of large-scale ecosystem

⁵ In particular we draw upon Watson's (2003) discussion in planning theory of "conflicting rationalities" (via Foucault), and how Rancière (2003) has conceptualized dissensus as tightly wedded to democracy as the rule by equals. We discuss this further under Section 5 where we elaborate "situational dissensus" in relation to Whatmore's (2009) careful studies of knowledge controversies (as inspired by Isabelle Stengers and Gilles Deleuze).

intervention.

In the following sections we turn to our empirical case study. We outline how drainage systems and shipping canals comprised *infrastructural zones* intended to predictably convey various flows of waste, water, and commodities across geographic variation. These zones fragmented urban space and generated peripheries while they simultaneously facilitated particular forms of global connection. However, to alter ecological relations through infrastructure can trigger profound environmental transformations to produce *ecological regime shifts*. In our case, regime shifts undermined flood protection systems and altered previous natural resource-based livelihoods, re-structuring social interests. Over time, these cascading effects coalesced into *socioecological cleavages*, whereby partitions in hydro-ecological systems and human communities impacted upon political and planning processes creating a *situational dissensus*. The final section narrates the politics within such a cleavage centering on the articulation of counter-expertise through collective action.

3. Infrastructural Zones and Ecological Change in the Mississippi River Delta

The long passage of time during which the vast Mississippi River Delta was formed plays a role in our historical account. As will become clear, time is not linear here; what happened a very long time ago can have an effect in the present. Standing in a vast saltmarsh, with no trees in sight, one might dig down a few meters and discover two thousand year-old stumps of the Bald cypress (*Taxodium distichum*), leftovers from previous versions of the deltaic environment when riverine and freshwater forces predominated. The inverse could also be true. A dense coastal forest might be growing atop a saline marshland buried by riverine sediments. Water moves not only across the surface of the delta, but invisibly through soil layers and organic materials. The dynamics of these underground flows are only now becoming better understood (Breaux et al., 2013; Kolker et al., 2013). In this way, any structural intervention in the deltaic landscape that involves major excavation or drainage, necessarily encounters not only the contemporary land cover pattern – but also millennia of deltaic dynamics that lie, materially real and vital, just beneath the surface. While many infrastructure interventions are designed to modify flows of surface water, engineers and managers constantly encounter the subterranean delta environment. In this sense, to carry out large-scale infrastructure interventions in these watery environments will necessarily connect and disconnect space and (deep) time to generate unpredictable effects in the present. Large-scale water infrastructures connect and disconnect both space and time. Geographers and other relational thinkers have described both time and space as “folded” or “pleated” – in that spatial relations are not necessarily based upon proximity, but are woven together through specific network relations that might be intimately connected but spatially distant (DeLanda, 2000; Jones, 2009; Murdoch, 2006). As we will see this produces a daunting task for planning.

3.1. – Historical Dynamics of the Mississippi River Delta

The Mississippi's immense drainage basin, the fourth largest on earth, drains two thirds of the continental United States. The Mississippi River Delta is a river/fluvial-dominated delta that produces vast and changing lobes of land. This gives the delta its iconic "bird's foot" that extends into the ocean and distinguishes it from wave or tidal dominated deltas like the Nile and Ganges-Brahmaputra Deltas. The Mississippi and its suspended sediments produced the entire landscape of South Louisiana over the last 6000 years (Figure 3). The Mississippi Delta is comprised of a few major distributary channels that have carried the main flow of the river during different episodes of lobe formation over the past 7,000 years. Hundreds of slow moving streams called *bayous*, some of which are former distributaries of the Mississippi, crisscross the delta. As delta lobes reach further into the Gulf over hundreds of years, a critical threshold called an avulsion typically occurs (usually triggered by a major flooding event). A major avulsion can shift the river's main course towards a shorter route and steeper gradient to reach the sea (Slingerland and Smith 2004). Deprived of new inputs of freshwater and sediments, the abandoned delta lobes begin to slowly compact, subside, and erode as they are exposed to wave action and tidal surges – a process referred to as saltwater intrusion, or marine transgression.

Figure 3. Historical lobes of the Mississippi River Delta. The lobe in pink to the east of New Orleans is the St. Bernard Delta, which is currently degrading and subsiding, placing communities at risk of flooding while simultaneously generating productive fisheries. The St. Bernard Delta is a focal area of this study.

The interplay of riverine and marine forces generates a spectrum of water salinity that subsequently drives habitat diversity. The ridgelines and “natural levees” that line the river’s main course and its abandoned distributaries might be covered with southern live oak and other hardwoods, and the soils in these locations are relatively stable and well-drained. Before the advent of modern municipal drainage, human settlement was almost exclusively concentrated on these “natural levees” and abandoned distributary ridges (Campanella, 2006; Colten, 2005).

Figure 4. Abandoned distributaries of the Mississippi River, Bayou Bienvenue, and Lake Borgne. The study area lies between the two abandoned distributaries and the Mississippi’s active distributary, which flows through New Orleans. Base imagery 2005, NASA Landsat 5tm.

However, our interest lies in the swampy depressions in between these ridgelines, which are referred to as *interdistributary basins* or *embayments*. The soils in these basins and estuaries are comprised primarily of wet clays and layers of swamp and marsh deposits left over from earlier manifestations of the deltaic system – when the area was receiving abundant flows of freshwater and fine silt particles in the form of suspended sediment carried from distant elsewhere of the North American continent. Where freshwater and riverine forces structure these interdistributary basins, coastal forests dominated by bald cypress (*Taxodium distichum*) and other aquatic trees are common. As tidal influence becomes stronger, trees give way to a range of fresh, brackish, and saline marsh grasses, submerged seagrasses, and floating marshplants. These tidal estuaries, with their salinity driven biodiversity, are important nurseries for marine species, provide habitat for a rich diversity of migratory birdlife, and have historically produced

incredibly abundant harvests eastern oyster (*Crassostrea virginica*) and brown shrimp (*Farfantepenaeus aztecus*).

The particular intertributary basin profiled here is a circa 600 km² estuary that lies between downtown New Orleans and Lake Borgne, an area we will alternately refer to as the “Bienvenue Basin” and the “Lake Borgne Estuary.” This area is displayed in Figure 4. Bayou Bienvenue, a slow-moving tidal creek, is the primary drainage feature of the basin, snaking its way along a fresh-saline water gradient. Many billions of dollars have been invested in the basin in the form of water infrastructure over the last century. These canals, levees, floodwalls, pumps, siphons, and river diversions have typically proved troublesome, spurring engineers to build increasingly complex layers of infrastructural zones meant to control the flows of water into and out of the basin. The policies and material practices guiding the construction and maintenance of these projects have been contested by nearby communities for over a century, giving rise to a popular skepticism towards water infrastructure planning emanating from state authorities. The following section documents this process in greater detail.

3.2. Contesting Infrastructural Zones: Pumps, Siphons and Ships

During the early 20th century a major controversy developed around the establishment of infrastructural zones in the delta. Here we trace this controversy between several engineering agencies, the Port of New Orleans, and peripheral communities (table 1). This dispute centered on the establishment of two different, and at times competing infrastructural zones. One aimed to change the landscape to promote global maritime trade. The other focused on providing urban sanitation, improving public health, and creating opportunities for urban expansion. Both were jostling to appropriate ecosystems through their respective infrastructures and technologies. The engineers of each viewed the city’s eastern periphery as a multi-functional landscape deemed capable of producing benefits, profits—and public services for the city, without taking much notice of peripheral settlements. Indeed, less visible was how the politics around the establishment of infrastructural zones in the Lake Borgne estuary came to reflect and reproduce long-standing distributions of social power and territorial control in the region. Indeed, our first section illustrates how infrastructural investments can generate not only disputes over planning power, but also trigger abrupt ecological shifts – sometimes irreversible sequences of environmental change felt by residents and later re-surfacing as politicized narratives of injustice.

Institution	Scope of Authority	Infrastructures of Concern
US Army Corps of Engineers 'Army Corps' <i>1800-Present</i>	US Federal Agency. Largest water manager in the US. Manages all major rivers and coastal ecosystems. Developer and regulator.	All large scale navigation, flood protection, and drainage systems in the region. Restoration projects, river diversions, etc. Premier water planning agency.
New Orleans Sewerage & Water Board 'S&WB' <i>1900-Present</i>	Municipal agency. Manages the drainage, sewer, and drinking water system of New Orleans.	The New Orleans urban drainage system, pumping stations, sewers, canals.
The Port of New Orleans <i>1718-Present</i>	State of Louisiana agency. Land use and water planning authority throughout metropolitan region.	Vast port facilities, navigation canals, railroad tie-ins, the Mississippi's channel.
Save Louisiana Coalition 'SLC' <i>2012-present</i>	NGO, coalition of fishing communities, local officials, seafood industry, scientists.	Potential river diversions, river dredging.
Restore the Delta Coalition <i>1980-present</i>	NGO, coalition of environmental organizations and scientists.	Focus broadly on 'restoration' projects, especially river diversions.
Louisiana Coastal Protection and Restoration Authority 'CPRA' <i>2005-present</i>	Louisiana state agency tasked with coastal planning and restoration.	Hundreds of coastal "restoration" projects involving shoreline protection, dredging, etc.

Table 1: Key institutional actors in coastal planning and infrastructure management in coastal Louisiana.

The Bienvenue Basin in the city's eastern periphery forms a good starting point to illustrate these competing infrastructural zones of public health/sanitation and maritime transportation. The former involves New Orleans drainage engineers' implementation of a modern municipal drainage system between 1900 and 1920. This promised to expand the city's footprint by draining groundwater from swamplands and improve sanitation and public health (e.g., reducing mosquito habitat), and produce space for urban development (Colten, 2005; Kelman, 2003).⁶ Crucially however, this infrastructural zone relied on aquatic ecosystems that had to be enrolled for sanitary systems to function properly. Prior to modern drainage, the swamplands that covered much of New Orleans modern footprint naturally drained into two different estuaries – Lake Pontchartrain to the North, and Lake Borgne to the east.⁷ The Lake Borgne and Bayou Bienvenue estuary,

⁶ Similar investments in the construction of comprehensive publicly financed drainage systems were widespread during the early 20th century, and some of the leading sanitary engineers consulted New Orleans authorities (Behrman, 1914; Melosi, 2000).

⁷ The City of New Orleans is contiguous with its county-level territory, referred locally as "Orleans Parish."

Figure 5. Inner Harbor Navigation Canal, also known as the Industrial Canal, first phase of Centroport. Left and right bottom renderings show the Industrial Canal at the time of its completion. Areas in red on bottom image show terminal space. Port officials envisioned a Rotterdam-style inner harbor for New Orleans. Top right photo shows Industrial Canal in 2005, facing north. The original 1923 locks, built by the Panama Canal's engineers, are still in place today, with some of the original equipment still functioning. Source: Historical renderings from New Orleans Public Library, Louisiana collection / City Archive. Photo courtesy Army Corps of Engineers.

lying along the eastern city limits of New Orleans, were chosen as a site for the “final disposal” of the city’s daily drainage. The effect was on one hand that the drainage system created sub-sea level drained polders, similar to those found in the Netherlands, which allowed for urban expansion beyond the natural levees of the Mississippi and other narrow ridgelines. While environmental historians and geographers have thoroughly described this process of terraforming and its effects within the city of New Orleans (Campanella 2006; Colten, 2005; Kelman, 2003), less attention has been paid to the other end of the pumps. This is, on the other hand, where drainage and sewage flows were sent into local estuarine systems in the city’s periphery to various effects, which we will return to later. Now we will instead turn to the maritime transportation infrastructural zone.

The city’s urban drainage system was implemented over the same period that the Port of New Orleans was pursuing the establishment of an infrastructural zone that focused on fundamentally transforming how maritime transportation functioned in the region. This plan in the early 1900s sought to relocate core port operations from publicly owned terminals on the banks of the Mississippi, to a public-private hybrid operation with terminals and infrastructure clustered along shipping canals dredged through the Lake Borgne estuary. Known in its later manifestations as “Centroport, USA”, port officials saw this project as their opportunity to build an “American Rotterdam” by reworking wetlands into a port complex positioned as a central node in global shipping networks thought to be revitalized by the successful excavation of the Panama Canal by US engineers in 1915 (Figure 5). Many of the leading engineers of the Panama Canal project were recruited to help design the first phase of Centroport, and the technical standards and water management practices developed in Panama were transferred to the Mississippi Delta (Carse and Lewis, 2017; Dabney, 1921).⁸

Taken together, it should be noted that maritime transport infrastructure and urban drainage infrastructure—both slated for implementation in the Lake Borgne estuary—were intended to produce better living conditions and open up new real estate in New Orleans. Further, they were geared to attract a larger share of global maritime trade through the port’s facilities and waterways. These projects were not necessarily in conflict with each other and both could provide increased public health, spatial expansion and capital accumulation in New Orleans. However, the estuary that these projects were attempting to enroll lay outside the city limits of New Orleans in neighboring St. Bernard Parish. This geographical contingency produced a conflict between port managers, drainage officials, and St. Bernard interests over the hydrological modifications, ecological transformations, and economic benefits associated with these projects, which will have far-reaching consequences as we trace this historical narrative further. As will become clear in the next sections, when these projects were rolled out in

⁸ The ship lock constructed at the intersection of the Mississippi and the Industrial Canal was designed by veterans of the Panama Canal project, and included a number of features identical to the Panama locks.

Figure 6. The city's main drainage canal and new Industrial Canal cross perpendicularly. Source: NOSWB. 1903.

New Orleans, they triggered not only ecological regime shifts but also laid the foundation for socioecological cleavages.

To select Bayou Bienvenue and Lake Borgne as the final disposal site for the city's drainage waters had both hydrological and territorial motivations. The original 1895 plan that sketched the general drainage scheme imagined the estuary as a promising receptacle for drainage flows, arguing that the area was:

... mostly uninhabited and a slight pollution of the water has no disadvantages. It is open to the Gulf [of Mexico], and the tides rise and fall more rapidly. The greater fluctuations cause a more complete dispersion and a more rapid removal of the drainage water... Bayou Bienvenu[e], which by dredging can readily be made of sufficient size to convey the drainage water, runs from the lake nearly to the levees of the city and can be utilized, without detriment, to receive the drainage flow. It is, also, *the natural outfall* for the drainage of a large part of the city. (New Orleans Advisory Board on Drainage, 1895: 24; our emphasis)

This arrangement was intended to keep pollution out of Lake Pontchartrain, which had become a popular spot for swimming beaches, resorts, and vacationing New Orleans residents. The city's chief surveyor and drainage official proposed the reclamation and development of the Pontchartrain lakeshore in 1874, a project eventually completed in 1930 (Campanella, 2002). The bayou's systemic qualities were thought to compliment the drainage removal and waste assimilation process, as evidenced in the description of the plan above. But by the time the canals, pumping stations, and waterway modifications were in place for

this scheme, the Port of New Orleans had begun excavating the first phase of their Centroport plan, the Industrial Canal connecting the Mississippi River and Lake Pontchartrain. The right-of-way for this shipping canal crossed the city's main drainage canal nearly perpendicularly (Figure 6).

The excavation of the Industrial Canal by the Port of New Orleans interrupted how tidal action operated in the region by adding a deep-water connection between Lake Borgne and Lake Pontchartrain. As a tidal stream, Bayou Bienvenue sometimes flowed towards Lake Borgne, and sometimes towards Lake Pontchartrain. The Industrial Canal and Lake Pontchartrain had less tidal influence, which meant that when the tide from Lake Borgne flowed up Bayou Bienvenue, it pushed into the Industrial Canal and into Lake Pontchartrain (NOSWB, 1916). For drainage engineers and municipal authorities, if sewage-laden drainage waters were pumped directly into the Industrial Canal, it would risk contaminating the Lake Pontchartrain shoreline.⁹ After the port's engineering team stated that they intended to dredge the shipping canal, they also agreed to construct a siphon that would carry the city's main drainage canal underneath the Industrial Canal, allowing for the continuance of the drainage flow to the eastern side and into Bayou Bienvenue (Lewis, 2015). The siphon was thus hailed by its designers as a technological fix needed for the infrastructural zones to function simultaneously in their politically desirable configuration, including to not contaminate the waters close to planned elite real estate projects along Lake Pontchartrain. The drainage siphon project itself was extraordinary complicated, taking three years to construct. Alongside this, drainage authorities invested heavily in transforming Bayou Bienvenue into their "Main Outfall Canal"—a name the stream retains on some maps to this day (Figure 6). This involved straightening the first kilometer of the bayou's course, clearing it of the numerous dead cypress trees which clogged its channel, and dredging its bottom to a depth of around 4 meters. Finally, they built a new drainage pumping station at the bayou's headwaters, and installed what they claimed to be the highest capacity drainage pumps on Earth (*Times-Picayune*, 15 May, 1916).

This spatial nexus of tidal ecosystems, the Mississippi River, an expansive industrial waterway, and one of the most complex urban drainage systems ever created were enrolled together in an tenuous attempt to produce several critical functions simultaneously, with the potential economic and hydrological benefits to accrue to urban interests in New Orleans. In reference to this achievement, a local journalist who often wrote with great admiration for engineers, wrote:

In New Orleans, Man has measured strength with Nature and conquered. He has thrown back the giant Mississippi and made it go where it listeth [wills] not. He has joined the river and lake, building gargantuan foundations for his work on the quicksands themselves. (Dabney, 1921).

⁹ The drainage and sewage systems in New Orleans are technically separate, but intermingling between the two systems has long been a problem. This is just a further illustration how technical expertise creates models that sometimes do not abide to historical reality.

But the entire relational ensemble envisioned by engineers in their maps and networks quickly proved to be both ecologically unpredictable and a source of political contention, even amongst the engineers themselves. The controversy centered on the potential construction of a barrier between Industrial Canal and Bayou Bienvenue. Drainage officials had been operating under the assumption that once the siphon underneath the Industrial Canal was completed in 1922, then the hydrological connection between Bayou Bienvenue and the Industrial Canal would be closed off by a dam, or a set of ship locks. Port officials, however, were interested in using Bayou Bienvenue as a shipping outlet to the Gulf of Mexico, but were not willing to make additional investments in water control infrastructure at the site. Several newly built ships used the bayou to reach the ocean during the First World War, but few ships utilized the bayou after that (NOSWB, 1921). The port's strategy with regard to enrolling Bayou Bienvenue in their port operations was to "test the waters," while holding out for a federal investment in phase two of Centroport – a deepwater ship channel through the same estuary which would effectively bypass the bayou. Until that project was developed however, port officials were content to send barges of coal and other bulk commodities through the bayou on occasion to justify keeping the hydrological connections in place. This vexed drainage officials for obvious reasons and a staff editorial in the city's leading newspaper described the predicament:

That waterway [Bayou Bienvenue], joining the Industrial Canal and Lake Borgne, can be either a *drainage ditch* or a *navigation canal* and it is for the city to decide which of the two purposes will be for the greater good of the city – not merely now but in that future time when New Orleans will have attained her full stature as a world port...Which of them shall be chosen? The uncertainty is almost as perplexing as that the maiden labors under when proposed to by rival lovers. She must pick one, knowing that divorces are expensive and unsatisfactory. Our only fear is that the city, like the young lady... may live to regret her choice. (Staff editorial, New Orleans Times-Picayune 1923; our emphasis)

In this passage we can note how the New Orleans elite saw the Lake Borgne estuary in terms of its utility for the "greater good of the city," despite the fact that most of the estuary lies outside 'the city' and in neighboring St. Bernard Parish. There, residents and public officials narrated the estuary as part of their livelihood and identity, placing it radically outside the narrow dichotomy of a "drainage ditch" vs. "navigation canal". St. Bernard Parish's economy, especially in the early 1920s, was dependent upon the area's swamps and marshes for much of its production. Muskrats, oysters, fish, waterfowl, and shrimp were at the core of both its economic vitality and its community identity. The inland reaches of the estuary, closest to New Orleans, were at the time dominated by freshwater swamp forests—dense stands of cypress and other wetland tree species. The estuary's fringe along Lake Borgne was primarily brackish marshes. This spectrum of salinity and vegetation supported abundant wildlife and biodiversity, critical to St. Bernard's economy and way of life. The reconfiguration of these ecological patterns by elite-driven infrastructure projects also disrupted fishing practices in

St. Bernard and initiated a persistent political situation that saw urban interests and peripheral communities at loggerheads.

As we've established, the city's drainage system was designed to convey water into the Lake Borgne estuary and avoid polluting Lake Pontchartrain. But without a gate or barrier between the bayou and the Industrial Canal, the drainage was taking a very peculiar route – passing underneath the western side of the Industrial Canal only to flow into it from the eastern side. If the port refused to construct a barrier between Bayou Bienvenue and the Industrial Canal, according to the city's frustrated drainage chief in 1921, the port would have "nullified the whole intent and much of the benefit of the city's main drainage project" (NOSWB, 1921). Writing a year later as the port refused to act, the drainage commissioner argued in his annual report that since "all important navigation has ceased to use [Bayou Bienvenue], it is recommended that the Dock Board be urged to close this cut or install a tidal gate in it to prevent the pollution of Lake Pontchartrain" (NOSWB, 1922).

As the ecological effects and spatial slicing up of the estuary began to come into focus in the early 1920s, fishing and hunting groups, landowners, and public officials from the Ninth Ward of New Orleans and St. Bernard Parish became vocal participants in the debate over hydrological connectivity between Bayou Bienvenue and the Industrial Canal. Between 1920 and 1935, St. Bernard officials found themselves briefly sharing hydrological interests with the Port of New Orleans. For St. Bernard, Bayou Bienvenue's connection to the Industrial Canal had two principal benefits. Firstly, it diluted the sewage-laden drainage flows coming from New Orleans and dispersed them in both St. Bernard and New Orleans waters, thereby ameliorating acute impacts to fisheries. Second, it was believed that the use of the bayou as the port's "Gulf Outlet" could transform swamplands in St. Bernard into lucrative space for maritime development and industry. While fishing groups may have taken exception to such developments had they materialized, in the short term their interests were also reflected in preventing sewage and drainage waters from overwhelming the estuary's fisheries.

After a series of public hearings regarding the issue, the City of New Orleans directed the Sewerage and Water Board to erect a dam between the Industrial Canal and Bayou Bienvenue in late 1926. In the spring of 1927, St. Bernard officials claimed that the damming of the bayou was already wreaking ecological havoc in the estuary. As one St. Bernard official lamented, "...the waters of Bayou Bienvenu have become stagnated and polluted, and following high tide, the waters flow over the lands...destroying all vegetation and timber in the territory affected and have destroyed the fisheries in Bayou Bienvenu as far as Lake Borgne, and shrimp waters in Lake Borgne" (Times-Picayune, 4 April 1927). The local newspaper noted the collective action forming among residents and officials in St. Bernard, remarking that "the movement to obtain relief from the menace occasioned by the polluted condition of Bayou Bienvenu is assuming concrete form" (Times-Picayune, 4 April 1927). These infrastructurally-induced

ecological changes mobilized peripheral communities against city agencies and sowed a regional dissensus that became increasingly difficult to address as the path dependencies associated with key hydrological decisions began to set in.

Throughout the 1920s and 1930s, St. Bernard officials worked with their elected representatives and a few allies at the Port of New Orleans to push for the removal of the dam, the abatement of pollution, and linking new maritime shipping routes through their territory. These efforts were unsuccessful. Part of the failure by St. Bernard officials to keep the two waterways connected is attributable to the expanding role of the US Army Corps of Engineers (hereafter Army Corps), a federal water planning agency which was gaining new authority to make centralized decisions regarding navigation, drainage, land reclamation, and flood protection. While signaling support for the excavation of a shipping channel between the Industrial Canal and the Gulf of Mexico, a senior Army Corps official sided with drainage and public health officials in New Orleans, questioning the suitability of Bayou Bienvenue as a shipping route due to its crooked and winding course and the instability of soils along its banks (Times-Picayune, 13 June 1929).

The debate around these infrastructural zones could be seen as a critical juncture in the development of regional environmental politics and ecological regime shifts. Most of the drainage waters of the city of New Orleans were concentrated in Bayou Bienvenue, with pumps and channel modifications in place to counteract tidal inflow and move wastewater away from the city's beach resorts, and towards Lake Borgne.¹⁰ Fecal bacteria levels, on the other hand, became concentrated in the oyster beds along Lake Borgne. Occasionally they reached dangerous levels and had to be closed, causing major inconveniences for oyster harvesters. These closures were occasionally triggered when facilities on the Industrial Canal dumped chemical pollution into the drainage system (and thus Bayou Bienvenue), leading St. Bernard officials to make threats, largely rhetorical, to construct a dam of their own on Bayou Bienvenue, which would theoretically at least, have forced the drainage system's outflow to spread over lands in New Orleans (Times-Picayune, 5 January 1972). Interestingly, over decades, the nutrient laden flows from pumping station No. 5 may have actually increased the yield of the Lake Borgne shrimp fishery, which became so highly productive in the areas where bayou waters intermixed with those of Lake Borgne, that coastal ecologists concluded that New Orleans drainage waters were generating increased productivity (El-Sayed, 1961).

Once the Port of New Orleans began working with the Army Corps to manage and expand the Industrial Canal into the next phase of the Centroport project, their interest in collaborating with St. Bernard on using the bayou as a shipping

¹⁰ It bears mention that the scheme to prevent pollution in Lake Pontchartrain also was a failure. The beaches along the Pontchartrain shoreline were closed on multiple occasions due to bacteria levels in the water. This became a serious problem as other suburban communities started pumping their drainage water into Lake Pontchartrain in addition to New Orleans. By the late 1980s, most of the beaches and lakeshore attractions had been closed and were rarely utilized.

canal waned. This effectively severed hydrological connectivity between the west and east side of the Industrial Canal, except for the sewage and drainage water being siphoned underneath it. The prospect of St. Bernard benefiting from the port expansion languished in uncertainty, while the flow of pollution and urban waste continued unabated. The excavation of the Industrial Canal severed the region into two large basins (or polders) with different hydrological influences. This division also coincided with significant ethnic, class, and racial patterns in the area. The neighborhoods on the western side of the Industrial Canal became mechanically drained and urbanized polders surrounded by levees. Areas on the eastern side of the Industrial Canal lagged behind considerably in terms of urbanization, population growth, and infrastructural investment (Landphair, 2007). This included not only St. Bernard Parish, but also the Lower Ninth Ward neighborhood of New Orleans. These areas also retained a stronger tidal influence and connectivity with the Gulf of Mexico through Lake Borgne, with greater exposure to high water events and storm surges. The hydrological and political effects of these projects began establishing divergent socioecological conditions on either side of the Industrial Canal, and formed the ground for political division.

The conjoined processes associated with the excavation of the Industrial Canal and the enrollment of the Lake Borgne estuary in the municipal drainage system triggered several ecological regime shifts (Table 2). These were modest in comparison to those triggered by the project's later phases, but included major fish kills in Bayou Bienvenue, the conversion of 31 square miles (80 km²) of primarily freshwater coastal forest within New Orleans to drained and impounded polders, which were subsequently urbanized and soils were compacted, sometimes below sea level. The excavation of the Industrial Canal converted 500 hectares (2 square miles; 5 km²) of coastal forest into open water and "spoil banks" where dredged materials were disposed.

Before we move on, it is important to highlight some of the theoretical points that this section has developed. What we witness is how water infrastructures function as a form of territorial and environmental governance. This involved two ostensibly separate infrastructural zones, maritime transport and urban drainage, jostling to enroll the same territory in their agenda. The massive fixed capital investments that these infrastructural zones embodied meant that managers became "locked in" to the politics and ecological dynamics of the areas their zones traversed. The political and material imperatives associated with maintaining the various networked elements of the infrastructural zones (gates, canals, locks, pumps, the bayou itself) also led to many subsequent investments in water control infrastructure aimed at maintaining the multi-functionality of the landscape, even as ecological systems began shifting in response.

One core aspect of the politics involved here lies in which functions the landscape will be managed to produce. This has been subject to debates and power asymmetries, as large institutional actors and public agencies in New Orleans have successfully secured outside funding and expertise through

	PHASE 1 Industrial Canal 1917-2014	PHASE 2 GIWW – 1942-Present MRGO – 1956-2009	PHASE 3 St. Bernard Channel & Lock - 1956-1977 Lock Replacement - 1956-Present
Infrastructural Zones	Canal between Lake Pontchartrain and Miss. River. 5.5 mile length, 30' depth, 500' width canal dredged through swamps, marshes, neighborhoods. Lock structure at terminus with Miss. River – 640' length, 75' width, 31.5' depth. Other features: levees , road and rail bridges , drainage and sewer siphons underneath canal.	Canal connection with Gulf Coast inland waterway, 9-14 foot depth, additional Gulf Outlet Canal, 75 miles length, 500' width, 36' depth. Other features: Public housing clustered near new port terminals. Levees from dredged materials.	Canal between Miss. River and MR-GO. 5.3 miles length, 50' depth. Lock structure 1200' length, 150' width, 50' depth. Levees, bridges , investments in community parks, greenspace, other urban infrastructure. Proposed ship lock scaled back in 2015, to serve only shallow-draft traffic.
Ecological Regime Shifts	Major fish kills in nearby bayous. Conversion of freshwater swamps to drained polders and canal beds. 55km² of cypress-tupelo forest converted to dredge spoil bank and open water.	Altered salinity and hydrological regimes across the region. 210km² of wetlands destroyed. 40km² of coastal forest converted to open water. Additional loss of 30km ² coastal forest near Manchac. Conversion of 260km² of Lake Pontchartrain bottom to a hypoxic "dead zone." Interrupted La LaLoutre Ridge, which regulated water salinity regionally. Loss of 65km² of marshlands due to dredge material disposal. Embankments formed by dredge disposal restricted sheet flow and hydrological regime in estuary. Overall shift of 64km² of freshwater dominated wetlands to brackish or saline marsh and open water.	Projects halted by collective action, Army Corps still seeking lock replacement on Industrial Canal. The waterways being "frozen" (neither rolled back or expanded) still has ecological effects as erosion, hypoxia, saltwater intrusion continue. Some effects of phase 2 were perpetuated by the political gridlock associated with phase 3.
Formation of socio-ecological cleavages and situational dissensus	Local elite work with national partners in Mississippi Valley to attract funds and expertise for canal and lock construction. Citizens groups, fishing associations, neighborhood associations protested infrastructure disruptions through formal petitions and at public hearings. Connectivity between Industrial Canal and Bayou Bienvenue became major site of contention with the Port and St. Bernard interests pressing to keep the two waterways connected. Drainage and public health officials in New Orleans prevailed, erecting a dam between the waterways in 1926.	Assemblage of Mississippi Valley states, port clients, maritime interests achieve Congressional authorization and funding of GIWW and MRGO projects. A broad coalition of local governments, civic groups, and environmental groups disrupted dozens of public meetings, lobbied politicians, and sought financial redress for damages. After Katrina, pressure on the port of New Orleans resulted in Congressional de-authorization of the MRGO project, and multiple engineered features to mitigate its effects on regional hydrology, storm surge, and salinity. (mrgomustgo.org)	Centroport clients and local elite press Congress for funds, downplay local resistance, offer to close MRGO in exchange for lock replacement. Multiple coalitions to contest the connecting channel and new lock / lock replacement successfully sought an executive order to cancel the connecting channel project. The lock replacement on the Industrial Canal has been help up in litigation by oppositional coalitions since the 1980s. Excavations associated with the lock replacement likely undermined adjacent floodwalls in the Lower Ninth Ward, where residents had cited concerns for decades that the replacement project might heighten flood risks from the Industrial Canal. Army Corps began new environmental review process on the lock replacement in 2015, proposing a "shallow draft" lock instead of the deepwater locks previously sought.

Table 2. Infrastructural zones, ecological regime shifts, and political contention associated with the Centroport USA initiative pursued by the Port of New Orleans between 1910 and the present, and the urban drainage system constructed during the same time frame. Ecological figures from Schaffer et al. 2009. Saltus et al. 2012.

government and private industry to enact their agenda. The ecological trajectory of the Lake Borgne estuary therefore, has been forged through a complex interplay between these water infrastructures, natural processes, and the maintenance of certain waterway standards. We can understand this initial investment by water managers in the estuary as overcapitalization, creating high-stakes dependencies between the city's critical urban infrastructures and the Lake Borgne estuary. From natural resource management literature, this can be interpreted as an example of "command and control" environmental management, a planning paradigm that Holling and Meffe (1996) have argued typically suffers from a number of pathologies as it is forced to confront its own socioecological contradictions. They argue that the territorial embeddedness of infrastructural zones and other command and control interventions commonly leads to a scenario in which "society becomes dependent upon command and control, demands it in greater intensity, and ignores the underlying ecological change or collapse that is developing" (Holling and Meffe, 1996: 328). This is certainly illustrated in our case study. Such interventions have also come to ignore the social dislocations associated with infrastructure; as much as an unexpected ecological shift might undermine the desired multi-functionality of a landscape, political resistance by nearby communities can also compromise the capacity of managers to embed new infrastructure, modernize existing features, and enact new forms of environmental management.

3.3. Training the Delta with Levees and Dynamite

Thus far we have traced how two extensive engineering projects, the New Orleans municipal drainage system and the first phase of the Centroport project were configured in such a way that benefits accumulated on the west side of the Industrial Canal, while environmental risks and ecological regime shifts were concentrated to the east side – in the Lower Ninth Ward, St. Bernard Parish, and the entire Lake Borgne estuary. These political decisions and subsequent material interventions formed a cleavage in the region's hydro-ecology and its polity. We now turn our attention to the management of the Mississippi River, and how controversies over the management of the river's flows during flooding events helped further solidify the socioecological cleavage between New Orleans and its eastern periphery. These events foreshadowed and helped produce the contemporary dispute over river diversions and coastal restoration infrastructure that we will return to later.

The concentration of undesirable flows in the territories east and downriver from New Orleans was not limited to sewage-laden drainage water. The Mississippi's natural tendency to break its banks and spread sediment across its alluvial plain has been subject to increasingly intensive infrastructural control and political mediation.

In the New Orleans area, the benefits and hazards associated with the infrastructural manipulation of the river's dynamics have reflected the territorial

dominance of the city's core public agencies and financial institutions over its periphery. A pair of historic river floods in the 1920's brought this dynamic into sharp relief. In April 1922, while Port officials were appearing to cooperate with St. Bernard Parish on maintaining Bayou Bienvenue as a short-cut to the sea, flooding on the Mississippi River compelled the same New Orleans-based port and maritime interests to take action to reassure nervous investors and port clients that the high water would not impact port operations and financial institutions in New Orleans. On April 27, 1922, the river levees failed at the town of Poydras in St. Bernard Parish, opening up a rift (or "crevasse") over 100 feet (30.5 m) deep in the riverbank, and carrying so much water into the adjacent coastal swamps and marshes that the river's overall level in New Orleans began dropping rapidly. Fears of flooding in New Orleans quickly subsided, and some engineers and New Orleans public officials began discussing the possibility of building control structures that would mimic the natural tendency of such crevasses to form in the riverbank during floods. A committee comprised of New Orleans newspaper owners, bankers, and port clients began pressuring officials in Washington DC to consider such infrastructures (Barry, 2007). While initially resistant to the idea of engineers creating artificial crevasses, the chief of the Army Corps of Engineers, said publicly in 1922 that instead of building control structures, which required massive capital outlays and maintenance costs, he would "...rather blow a hole in a levee, if conditions became serious, and let the water take care of itself" (Barry 2007, 168). Some residents of St. Bernard Parish looked with suspicion on the 1922 crevasse, wondering if New Orleans interests may have intentionally undermined the levee to cause the crevasse (Barry, 2007).

Five years later, the worst flooding along the Mississippi River in modern history occurred, displacing hundreds of thousands of people, mostly African-Americans, along the river's lower course (Hornbeck and Naidu, 2014). Floodwaters collected in the tens of thousands of tributaries in the vast Mississippi Valley, and a series of levee failures began occurring in Arkansas, Mississippi, and finally, Louisiana. As the flood's crest moved towards New Orleans, the city's elite again took steps to reassure investors and port clients that the city would be safe from any major flooding and operations would not be impacted significantly (Barry, 2007). Further, engineers voiced serious concerns over the new ship locks that connected the Mississippi River to the Industrial Canal. Completed in 1923, port managers feared the lock gates might be overtopped or otherwise compromised by high water in the river. The destruction of these locks would have been a massive financial and operational loss for the port, who, as we have mentioned, were in the process of moving many of their facilities and operations onto the Industrial Canal and were pursuing federal funding for the second phase of their Centroport project – a new shipping canal connecting the Industrial Canal to the Gulf of Mexico. As the river rose, St. Bernard Parish mobilized hundreds of men to guard river levees, as speculation circulated that New Orleans-aligned interests might attempt to open a breach in the levees there. The levee guards actually opened fire on a small river vessel near Poydras, killing one of its passengers (Barry, 2007). Engineers tracking river conditions in the spring of 1927 eventually concluded that breaches in the river

far upstream from New Orleans were lowering the river's peak level in New Orleans, thereby preventing any flooding of the city. Undeterred, the financial elite of New Orleans and the city's major newspapers pushed ahead with a plan to "blow the levee" near Poydras, at a village named Caernarvon. They mobilized their connections within national engineering agencies and political networks to ensure that the Army Corps and the State of Louisiana were behind the plan, which left opponents in St. Bernard with little choice but to watch as engineers set off dynamite in the levee and a torrent of river water poured into the swamps, marshes, and coastal communities of lower St. Bernard Parish (Figure 7). The Parish president, after watching the dynamite go off, remarked to the many onlookers that they had just witnessed "the public execution of this parish" (Barry, 2007: 257).

Figure 7. The Army Corps detonates the levee at Caernarvon, 1927. This event became synonymous with the territorial dominance of New Orleans in the water politics of its periphery. Source: NOAA.

The flood of 1927 also signaled the advent of centralized, command and control management of the entire Mississippi river system. When the US Congress passed the Flood Control Act in 1928, it positioned the Army Corps of Engineers as the central agency in charge of managing the entire course of the Mississippi River. This program relied upon levees and large flood control outlets and aspired to manage the dynamic river by accounting for the flow volumes passing through its various tributaries and distributaries.¹¹ From 1927 until today, river management aims to prevent flooding of communities and maintain favorable

¹¹ Perhaps influenced by resentment from residents of the majority white St. Bernard Parish over the 1927 flood, the plan included an artificial outlet structure a few miles upstream of the city. This spillway, called Bonne Carré, instead involved the periodic inundation of two African-American cemeteries where slaves and later free black people had lived and worshipped.

conditions for the thousands of ships and barges that utilize the Mississippi River system for waterborne commerce. This system of flooding outlets and control structures was not fully implemented until the 1970s, but its completion underscored a commitment by the US Government that the Mississippi River would remain locked in its present course, and its tendency to periodically abandon its primary distributary would be prevented. The levees and control structures on the Mississippi also ensured that its freshwater and sediments stayed put, except during rare and extreme floods. During those emergencies, much of the river's flow could be diverted through several outlet structures, sending floodwaters through sparsely inhabited areas that were managed as "floodways."

The implementation of this infrastructural zone fundamentally altered the river delta's historical dynamics by holding its channel in a fixed course and concentrating its floodwaters in a few outlets. This achievement by the Army Corps served to place millions of people out of the reach of the river's floodwaters, but in interrupting the river's capacity to build its own delta, the Mississippi River levee system accelerated the pace at which remaining coastal wetlands and estuaries were subsiding and eroding into the sea. Furthermore the intentional breaching of the levees in 1927 validated the suspicions of many St. Bernard Parish residents with regard to the territorial dominance of the Port of New Orleans over the parish's hydrological affairs. This has led to accusations over the subsequent decades of the Army Corps intentionally flooding the city's periphery to secure its core population and critical infrastructure. The story of the 1927 dynamite-crevasse at Caernarvon makes such accusations plausible from the point of view of St. Bernard residents. The 1927 crevasse decimated fur trapping in the Breton Sound estuary, just adjacent to Lake Borgne. While muskrats, mink, and otters prefer freshwater conditions, the intensity of the floodwaters coursing through the crevasse caused widespread mortality amongst these key commercial species, the sale of which accounted for a substantial portion of the parish's economy prior to 1927 (Barry, 2007). Thus, as urban-centered water management again compromised livelihoods in St. Bernard, a political culture of skepticism towards infrastructural interventions championed by New Orleans interests and federal engineering agencies was beginning to take root.

3.4. Enrolling the Lake Borgne Estuary into "Centroport, USA"

The second phase of Centroport produced the project's most enduringly transformative effects in regards to infrastructural zones, ecological regime shifts, and socioecological cleavages (Table 2). The Gulf Intracoastal Waterway, dredged during the early 1940s, provides a standardized inland shipping channel along the length of the US Gulf Coast from Florida to the Mexican border. The route of this channel essentially replicated that of Bayou Bienvenue, but straighter, with standardized dimensions, and without the complication presented by the pollution from the New Orleans drainage system. This also effectively impounded the drainage flows entering Bayou Bienvenue to the

southern portion of the Lake Borgne estuary, in St. Bernard Parish. A decade later, the port scored a massive public subsidy when Congress approved funding for the Mississippi River-Gulf Outlet (MRGO). The “groundbreaking” ceremony, organized by the Army Corps and port officials, involved setting off a charge of dynamite in the coastal cypress forests the channel was to traverse (Figure 9). Between 1957 and 1963, the MRGO was dredged 122 km through the Lake Borgne and Breton Sound estuaries, connecting the Industrial Canal with the Gulf of Mexico (Figure 8). As Figure 9 illustrates, local port clients (Standard Fruit, in this case) hailed the construction of the MRGO as an improvement upon the connectivity offered by the Mississippi River (Azcona, 2006). The MRGO severed the ridgeline formed by Bayou La Loutre, an ancient distributary of the Mississippi, which had historically regulated salinity between the Lake Borgne estuary and the Breton Sound estuary. This permitted seawater to creep along the canal bottom and into the brackish and freshwater ecosystems along Bayou Bienvenue (Saltus et al., 2012; Shaffer et al., 2009).

Figure 8. Position of MRGO (blue) and GIWW (green) in reference to the study area. Bayou Bienvenue marked in green. Levees in red. Note the “funnel” shape formed by the confluence of the two channels. A new storm surge barrier was constructed here following Katrina. Base imagery 2015 Landsat 8.

Officials in St. Bernard, while voicing some initial support for the MRGO project, became resolutely opposed to it as the Army Corps dredges began cutting their

way across the Parish's estuaries. In 1957, the year before dredging officially commenced on the MRGO project, the St. Bernard government weighed in on the impending project with clear concerns over its impact on the parish's coastal landscapes:

The upper reaches of the Parish heretofore have been protected from excessive tidal waters due to the slowing down action of the outer marsh areas. However, with the existence of a channel 40 feet [12 m] deep traversing the marsh lands from the Gulf to the upper Parish, the full fluctuation of the tide will be felt throughout the Parish. The tidal action will have adverse effects on the entire marsh area with consequent erosive action and the intrusion of high saline content water into areas normally fresh or only slightly brackish. During times of hurricane conditions, the existence of the channel will be an enormous danger to the heavily populated areas of the Parish due to the rapidity of the rising waters reaching the protected areas in full force through the avenue of this proposed channel. This danger is one that cannot be discounted. No matter how small a flood may be, or how small the area to which it is confined, to the families that have water in their houses, it is a major catastrophe (St. Bernard Police Jury, 1957, as quoted in Shaffer et al., 2009).

This passage demonstrates that St. Bernard officials were keenly aware of the risks posed by the MRGO, and their analysis was indeed prescient with what transpired during Hurricane Betsy in 1965, and Hurricane Katrina in 2005.

Figure 9. Advertisement hailing completion of MRGO canal by the Standard Fruit company (left). Source: Times-Picayune, 23 July 1963. Image on right shows group of engineers and port officials at the MRGO's "groundbreaking" in 1957. The coastal forests they dynamited here succumbed to salinity stress following Hurricane Betsy in 1965. Source: USACE

For Centroport to achieve its goal of attracting deep-water maritime trade through the Port's tidewater facilities, officials saw a need to expand or replace the ship lock that connected Centroport to the Mississippi River in the Lower Ninth Ward. As typical freighter sizes grew rapidly after the Second World War, the ship lock on the Industrial Canal, protected at St. Bernard's expense in 1927, was too small to accommodate the largest cargo ships of the day. If the port was to complete its transition from the riverfront to Centroport's tidal canals, engineers insisted that a larger ship lock had to be built somewhere – either a replacement lock at the existing lock site in the Lower Ninth Ward, or at a different location downstream in St. Bernard Parish.

The first Army Corps plan for an expanded lock called for a new lock structure and an additional shipping channel through lower St. Bernard Parish near the town of Meraux, about 4 miles (6.4 km) upstream from the site of the 1922 crevasse at Poydras. Opposition to this new lock and connecting channel was highly organized and unified amongst St. Bernard residents and public officials (Mazmanian and Nienaber, 1979; Shallat, 2000), demonstrating a capacity to mobilize collectively on water infrastructure issues.

Anti-New Orleans sentiment in St. Bernard Parish has origins beyond struggles over infrastructure. Racial segregation and the politics of white supremacist populism are also an important facet of the cleavage that emerged between the two municipalities. At the time of the first public hearings on the project in 1960, major demographic shifts were taking place in St. Bernard Parish that signaled its growing urban and suburban character, and budding political influence in state politics (Germany, 2007; Jeannsonne, 1997). The New Orleans public school system was one of the first in the Deep South to end formalized racial segregation of its students (Landphair, 1999, 2007; Wells, 2004; Wieder, 1987). Schools in the Ninth Ward of New Orleans, home to primarily working class residents, were selected by the city's school board as the test sites for the policy, which began in 1960. The integration process saw white parents boycotting the integration process and holding protests outside schools as a selected few African-American students, all girls, walked through the crowds under armed guard to attend classes. Participation in the boycott by white families was near 100% (Jeannsonne, 1997). Many Ninth Ward residents felt compelled to avoid integrated schools entirely, and officials in St. Bernard and Plaquemines Parishes, long a site of strict racial segregation and domination by a small group of white landowners, offered incentives for white Ninth Ward children to attend its public schools, where racial segregation was being preserved through careful legal maneuvers and posturing by Parish officials, a system of segregation lasting until 1989, over 30 years after the US Supreme Court ordered public schools to integrate (Wells, 2004). Federal officials took multiple opportunities to put pressure on St. Bernard Parish to integrate its schools and end discriminatory housing policies, leading to local officials publicly berating the federal government for its interventions in the parish's internal affairs (Wells, 2004; Jeannsonne, 1997). These confrontations presaged the contemporary opposition to federal water resources planning and river diversions.

The white residents of the Ninth Ward moving to St. Bernard in large numbers were already familiar with the environmental and economic grievances voiced by St. Bernard officials towards the New Orleans drainage authorities, the Army Corps, and the Port of New Orleans. Residents of the Ninth Ward had dealt with all manner of disruptions in drainage and sewer services during the excavation of the Industrial Canal, which left some sewer lines overflowing and stagnant for nearly three years while the siphons were completed (NOSWB, 1921). The civic associations in St. Bernard and the Ninth Ward communicated regularly on environmental concerns beginning in the 1920s, often acknowledging their shared frustration over policy decisions made by public agencies in New Orleans (Times-Picayune, 17 February 1923). Many Ninth Ward residents were also recreational fishermen and hunters who regularly made use of Bayou Bienvenue and the Lake Borgne estuary. A fishing association that worked to improve environmental conditions along Bayou Bienvenue boasted hundreds of members in the 1920s, and was headquartered in the Ninth Ward (Times-Picayune, 27 February 1921). Between 1960 and 1980, thousands of residents of the Ninth Ward and other neighborhoods of New Orleans settled in suburban subdivisions in St. Bernard Parish.

As white residents left the Ninth Ward in large numbers, African-American residents were simultaneously moving in. The Centroport plan included provisions for housing laborers, despite the transition away from large labor forces in the port industry already occurring in the 1960s, a trend greatly accelerated by the advent of containerized shipping (Cowen, 2014). The swampy depression near where drainage water was siphoned underneath the Industrial Canal was actually a small remnant of Bayou Bienvenue's former basin, bisected by the Industrial Canal. Prior to modern drainage, this area had been off limits for development due to its flood prone topography and unstable soils, but two large federal public housing projects, named *Florida* and *Desire*, were constructed there between 1940 and 1960. Before 1940 almost no one lived in this former cypress swamp. By 1965 it was the most densely populated neighborhood in New Orleans as black residents displaced by slum clearance projects elsewhere in the city took advantage of the low-cost apartments the developments provided (Breunlin and Regis, 2006). This simultaneous eastward migration placed thousands of people in flood vulnerable terrain when Hurricane Betsy struck the region in 1965. The storm surge devastated much of St. Bernard Parish and the Ninth Ward of New Orleans (Shallat, 2000; Azcona, 2006). The drainage siphon under the Industrial Canal failed and flowed backwards under tidal pressure, flooding the Florida and Desire projects, along with thousands of other homes on the west side of the Industrial Canal.

Hurricane Betsy killed hundred of people and caused more property damage than any storm in US history up until then. In response, flood protection agencies made new investments in flood control infrastructure in the Lake Borgne estuary (Colten, 2005). Betsy also triggered ecological regime shifts in the Lake Borgne estuary (Saltus et al., 2012) and galvanized the communities along New Orleans'

eastern periphery against the third phase of the Centroport plan (Shallat, 2000; 2014). Betsy demonstrated how storm surge posed a serious threat not only to the coastal zone, but also to New Orleans itself. Having secured the city from the threat of riverine flooding following 1927, the Army Corps set its sights on preventing storm surge flooding after Hurricane Betsy, proposing an elaborate system of concrete floodwalls, earthen levees, and other structures. Immediately following the storm, St. Bernard officials placed the blame for the storm surge's severity on the MRGO, which had recently been put into commission when the storm surge struck. Army Corps officials denied that MRGO had any role in the flooding, but Betsy catalyzed what became a fifty-year struggle by St. Bernard residents to close the channel and address the changing ecological conditions in the region (Times-Picayune, 15 March, 1967). The adversarial politics of blame following Betsy were yet another contributor to the formation of a socioecological cleavage between areas on either side of the Industrial Canal.

3.5. Centroport's Failure and Ecological Legacy

Many ecosystems are dependent upon particular temporal patterns of disturbances. Fluvial-dominated river deltas like that of the Mississippi typify this as they require regular pulses of freshwater and sediment across their deltaic plains to remain above the level of the sea (Tessler et al., 2015). Carried forth by technical standards, infrastructural zones have become embedded within these deltaic systems in and around New Orleans. This has, on the one hand, altered the temporal patterns and territories through which riverine flooding operates, transforming what was a frequent occurrence into a relatively rare and infrastructurally mediated event. These same infrastructural zones have become articulated with the increasing encroachment of oceanic forces and acute pulses of saline water. Saltwater intrusion (or marine transgression) is an historical ecological process that proceeds through what some non-equilibrium ecologists refer to as an interaction between "slow" and "fast" variables—increasing gradually through coastal erosion, and in times of storms and hurricanes, as acute, "fast" pulses. Ecosystems can rapidly shift in response to these acute events. Freshwater ecosystems that have emerged and been reproduced over thousands of years in the vicinity of New Orleans, depend upon regular freshwater and sediment inputs from the Mississippi River, a mechanism that distributes sediments and displaces tidal action. By 1965, marine transgression was accelerated by saltwater intrusion associated with canal excavation, and the freshwater and sediments that would in previous eras mitigate this land loss, were held captive behind the Army Corps' flood protection levees along the Mississippi River.

The freshwater ecological systems at the far inland reach of the Lake Borgne estuary, where Bayou Bienvenue met the Industrial Canal, underwent an ecological regime shift between 1956 and 1978, much as the St. Bernard government and coastal scientists had predicted. The storm surge that entered this basin during Hurricane Betsy became trapped between the Industrial Canal floodwalls to the west, and the levees, elevated roads, and landfills to the east

(Saltus et al., 2012). Coastal forests like those that dominated this area are typically resilient to storm surges if the salinity shock is brief. Surge waters eventually recede, and precipitation-induced runoff associated with the hurricane might also create freshwater flows that flush surge out of freshwater ecosystems (Tiner, 2013). But the infrastructural zones built and anchored by the Army Corps and other flood protection agencies over the years prevented these processes from taking place. The result was that nearly every bald cypress (*Taxodium distichum*) tree in the area was dead within ten years of Hurricane Betsy (Saltus et al., 2012; Shaffer et al. 2009). As the canopy died out, only large ponds of open water and fragments of brackish and intermediate marsh grasses remained. These landscapes are less capable of buffering tidal flows and storm surges than coastal forests.

Centroport's canals were thought by their architects to promise a less dynamic biophysical context than the Mississippi River. Instead, engineers found that their interventions tended to exacerbate already existing issues like subsidence and saltwater intrusion, presenting them with a shifting ecological baseline that offered a less favorable situation for maritime industries and port terminals, including flood risks and unstable soils. The lands that Centroport's canals traverse is an expanse of peaty soils, posing significant challenges for laying foundations for small homes, much less large industrial facilities (Dokka, 2011; Snowden et al., 1977). The fact that the estuary in question had soils made up primarily of so-called "fat clay" made it prone to a process called *sloughing*, in which levees and other structures built atop these soils cause the lateral displacement of subsurface layers. Every time the Army Corps dredged the bottom of the channels and deposited this material on its banks, the added pressure from this material would push soil back into the bottom of the channel (Seed et al., 2006; Shaffer et al., 2009). In some locations, the original 500-foot width of the MRGO channel became over 1000 feet (i.e., widening from 150 m to 300 m), as the banks of the canal were exposed to ship wakes and eroded into the channel (Shaffer et al. 2009).

Once the initial investments in canal infrastructure were made, billions of dollars in additional infrastructural investments followed in the form of flood control systems and ecological restoration measures devised to mitigate the flooding hazards, soil instability, and ecological changes brought on by the canals themselves – a layering and interrelating of the material path dependencies associated both with ecological regimes and infrastructural zones. More and more state capital became bound up in Centroport's infrastructures, despite the fact that by the 1980s it was clearly failing to generate economic returns (Azcona, 2006; Gramling et al. 2011). Centroport attracted much less traffic than port officials anticipated, and their limited depths prevented the massive ships being built by the 1980s, from using Centroport. Attempts to convince the US Congress to fund the deepening of the MRGO and Industrial Canal were unsuccessful, in part because of vocal opposition to the projects by residents of St. Bernard Parish (Mazmanian and Nienaber, 1979).

The dynamics of contention around Centroport illustrate the power of port interests to act collectively to generate and respond to political opportunities and attract state capital and compete for maritime traffic, but also, since the 1960s, the power of local groups to contest and indeed shape port development policy. As we saw in our account of the 1927 flood on the Mississippi, maritime transportation and its related industries comprise a hegemonic assemblage of political, economic, and cultural power in New Orleans and the state of Louisiana, which for many decades had a relatively free hand in reworking the region's waterways (Barry, 2007; Freudenberg et al., 2009b; Azcona, 2006; Lewis, 2015). Since the 1920s, this powerful network of businesses, elected officials, and port agencies has relied upon the hydrological engineering expertise of the Army Corps of Engineers to produce and maintain an infrastructural zone made up of a matrix of land and water conducive to the demands of global maritime transport. New Orleans port officials have built effective political coalitions comprised of key leaders and business interests in the Mississippi Valley, where agricultural exporting states rely upon the Mississippi River and New Orleans to transfer their bulk commodities to ocean liners. New Orleans's position at the bottom of an extensive, navigable, and fertile river basin has for centuries driven its competitive advantage over other Gulf Coast ports, and nurtured a system of political advocacy and patronage that for decades reliably delivered federal support for infrastructural investment and navigation projects (Azcona, 2006; Freudenberg et al., 2009a; Freudenberg et al., 2009b; Gramling et al., 2011). The port's maritime connectivity with the Caribbean has led to many private industries like the Standard and United Fruit Companies having their headquarters in New Orleans, and with the support of the US military, exerting considerable influence in the geopolitics of Central America (Azcona, 2006).

The emergence of the environmental movement since the late 1960s and the establishment of legal tools that empower communities to contest certain aspects of the implementation and maintenance of federal water resources projects have seriously challenged the dominance of these maritime and financial interests, and further entrenched the rancorous politics between New Orleans and St. Bernard Parish. The passage of the National Environmental Policy Act (NEPA) of 1969 reconfigured political opportunities for the growing numbers of residents, coastal communities, and environmentalists, who were alarmed at the rapid ecological and hydrological changes that Centroport was inducing. While formal community opposition to Centroport began in the early 1920s when Ninth Ward residents protested drainage disruptions triggered by the dredging of the Industrial Canal,¹² local residents had very little formal power to obstruct or constrain the port's agenda until NEPA placed new regulations on water infrastructure projects nationwide and provided a legal framework for opponents to examine the activities of the Army Corps and other water planning agencies. The critical third phase of Centroport – the replacement lock and connecting channel slated to be cut through St. Bernard Parish – has been tied up in litigation and regulatory review since 1977, when US President Jimmy Carter

¹² "Lafayette Avenue Sewerage Offends" New Orleans Times-Picayune. July 9, 1920.

ordered systematic review of dozens of water resources projects (Mazmanian and Nienaber, 1979). Since this time, the collective capacity of port interests has been weighed against the capacity of community groups and environmentalists to translate local grievances to the level of legal challenges to national water resources projects. This is one dimension of the politics of socioecological cleavages. Figure 10 shows a flyer produced by a neighborhood association in the Lower Ninth Ward, which has since the 1980s opposed the expansion of the ship locks on the Industrial Canal, citing concerns over flooding, neighborhood disruption, and the excavation of toxic sediments on the canal's floor (USACE, 2009).

Figure 10: Flyer from 1990s protesting the replacement of the lock on the Industrial Canal. Neighborhood groups in the Ninth Ward have successfully prevented this project from moving forward since the 1970s. Source: Courtesy of Citizens Against Widening the Industrial Canal.

Opponents have been remarkably successful in limiting further expansion of Centroport, but the ecological regime shifts it had already triggered by the 1960s were difficult to reverse, especially with the existing canals still in operation. Long-time activists who opposed Centroport described this frustration in our interviews with them. While US environmental laws made slowing down the expansion and modernization of Centroport, the decommissioning of an existing and operational project is considerably more difficult to achieve.

Take for example, the Mississippi River-Gulf Outlet (MRGO). Decommissioning and closing a canal maintained by the Army Corps requires action by the US Congress. While Congress has been receptive to arguments from Centroport's promoters that the project had national economic and military significance, opponents of the project were long denied the same listening ear. Despite dire warnings from dozens of scientists, environmentalists, and coastal communities that the MRGO was a "hurricane highway," the Port of New Orleans continued to support and promote the project, and the Army Corps continued to faithfully maintain it to its standardized dimensions by dredging bottom sediments and dumping them elsewhere. The Port of New Orleans refused to consider closing

the MRGO as long as the third phase of Centroport remained tied up in legal challenges from environmental and community groups (Slawsky, 2004). As an Army Corps official put it in 2004, “[o]f course the Mississippi River Gulf Outlet is an environmental travesty...the unfortunate thing is that the New Orleans area is not in a position to be able to afford the economic loss of just shutting it down” (Slawsky, 2004).

This third phase of Centroport now hinged increasingly on the old 1923 lock on the Industrial Canal, which had gradually become what transport geographers refer to as a “chokepoint” within the wider waterborne transport system. The lock limited maritime circulation, but was not easily bypassed due to the centrality of the Mississippi River in the inland waterway system. Without the MRGO open and dredged, large ships would not be able to access the Industrial Canal and existing Centroport terminals, and those facilities would thus need to be relocated to the Mississippi River (Slawsky, 2004). The maritime transport infrastructures along the Centroport canals represented a substantial investment in fixed capital, all sitting behind an aging and narrow ship lock on one end, and on the other, a shipping channel with chronic soil stability problems which demanded expensive, continuous dredging. As opponents effectively stopped Centroport’s third phase between 1960 and the 1990s, the project was becoming more of a liability than an asset for the Port of New Orleans. In the mid 1980s, port officials decided to build a new container-handling terminal along the Mississippi riverfront in uptown New Orleans. This signaled the port’s move to begin investing in critical infrastructure along the Mississippi riverfront, and shifting their infrastructural investments away from Centroport and the Lake Borgne Estuary (Katz, 1984). Given the flooding risks and ecological regime shifts associated with Centroport, some residents wondered if it was time to close the MRGO altogether. As a resident from the area remarked in a 1988 editorial:

If we had a hurricane from the southeast that would cause water to surge up the MRGO, and [sic.] the devastation would be enormous. It is not too late to fill in the MRGO and re-establish the marsh as a buffer against the tidal surge of a large hurricane. Let us begin correcting the mistakes of the past and insist the [Army] Corps fulfill its obligation to this region (Times-Picayune, 14 December, 1988: A-22).¹³

But port officials and the Army Corps continued to keep the MRGO open, dredging its channel to its standardized depth of 36 feet (11 m), and in later years, dumping massive quantities of concrete and stone along its banks in an attempt to prevent ship wakes from further eroding the surrounding marshlands.

As we observed throughout this section of the paper, layering infrastructural interventions in a biophysically dynamic context like the Lake Borgne estuary can lead to one infrastructural zone undermining the functionality of another. This

¹³ That the Times-Picayune, once the MRGO project’s chief public booster, began printing editorials critical of the Port’s investment strategies demonstrates how the project’s light had faded in just two decades.

shows how the complex interplay of infrastructural zones and ecological regimes steers hydrological processes and has real impacts for the region's populace. After pushing to break ground on the third phase of Centropoint since 1960, the project received some limited funding to prepare the replacement lock site in the Industrial Canal in the late 1990s, over the objections of many Ninth Ward residents (Figure 10). The Army Corps hired a contractor to prepare the site along the Industrial Canal where a bypass channel associated with the new locks was to be excavated. The Industrial Canal was equipped with concrete floodwalls following Hurricane Betsy, and the demolitions and excavations carried out to make room for the bypass channel took place along a kilometer long section of this floodwall. Long wooden pilings, underground storage tanks, and other utility connections were excavated and removed. A report by a group of respected engineers claims that the improper backfilling of these excavations was a key factor in the catastrophic nature of the levee breaches at this location in 2005 during Hurricane Katrina (Bea and Cobos-Roa, 2008; Seed et al., 2008). According to these engineers, after pushing up along the "funnel" created by the intersection of the MRGO and the GIWW (Gulf Intracoastal Waterway), storm surge waters entered the Industrial Canal. Storm surge then pushed into improperly backfilled excavations made at the site, and entered a permeable layer of ancient swamp and marsh deposits. This caused water to seep underneath the floodwall to loosen it until it fell over with massive amounts of water rushing in. In the words of the engineers:

Removal of barges, piles, underground storage tanks, and underground utilities (e.g. sewer, water, gas lines) reached to and substantially exceeded elevations of -10 ft [3.1 m] to 25 ft [7.6 m]; thus intersecting the underlying marsh deposits. When backfilled with porous - pervious - materials, hydraulic connections were developed between the backfilled excavations and the buried pervious - permeable marsh and swamp layers (Bea and Cobos-Roa, 2008).

The breach that occurred was the most catastrophic of all the failures in the flood protection system during Hurricane Katrina in 2005, carrying a wall of water into the Lower Ninth Ward and St. Bernard Parish that obliterated entire city blocks, moved homes off foundations and placed them down the street. Even without these catastrophic failures, these neighborhoods would still have suffered flooding, and there is some debate amongst the engineers who examined the levee failures after Katrina as to whether water seeping under the floodwall caused its failure, though a majority believe that it was (Seed et al., 2008).¹⁴ It is worth noting here that some residents of the Lower Ninth Ward voiced publicly their belief that the US Government dynamited the floodwall in their neighborhood, in an effort to prevent the flooding of affluent neighborhoods and critical urban infrastructure (SBC, 2006). This reflects the widespread belief east of the Industrial Canal that the US Government and its allies in New Orleans are willing to sacrifice certain communities to preserve

¹⁴ A lawsuit against the Army Corps and their contractor by residents seeking compensation for flooding damages was rejected by a judge in 2013, though the dispute between engineers over the cause of the breach continues and litigation associated with these excavations is ongoing.

their own interests. The events of 1927 reveal this to be at least grounded in historical events, even if such accusations of intentional breaches are baseless with regard to Katrina. This demonstrates how infrastructural zones can not only undermine ecological processes in the systems in which they are embedded, but also disrupt the functions of related infrastructural networks designed to provide flood protection or drainage and further deepen socioecological cleavages.

When Hurricane Katrina's storm water surge devastated the entire Centroport footprint and catastrophically flooded nearby communities, the structure of political opportunities again shifted, and opponents to the project were able to mobilize their elected officials and Congressional leaders that the MRGO was a major culprit in the flooding, and should be closed with or without the replacement lock. In 2008, the US Congress ordered the Army Corps to close the channel to ships permanently, and funded the construction of a rock barrier that would close the gap and recreate the ridgeline that formerly regulated salinity in the estuary. In 2010, the largest storm surge barrier in the United States was constructed directly across the MRGO and GIWW. The new closure structures almost immediately impacted salinities across the entire region (Poirrier, 2013). Lowered salinities near New Orleans have led local groups to experiment with replanting cypress-tupelo trees in an effort to restore the ring of storm surge buffering coastal forests that existed in the area prior to Centroport's construction. The pattern of flood risk that persisted for most of the 20th century, in which the city's eastern periphery was disproportionately exposed to hurricane storm surges has culminated in the construction of the most expansive flood protection system in the US (discussed further below), and again effectively split the Lake Borgne estuary in half. On one side of the floodwalls, marine processes predominate. On the protected side of the floodwalls, tidal influence has decreased, and plans are under development to introduce massive pulses of freshwater and river sediment into this protected side of the estuary, aimed at creating elevated substrate for fresh marsh and coastal forest plants to take root.

As ecological regime shifts played out throughout the Lake Borgne estuary in the 20th century (Figure 11), it would have been difficult to read the changes as anything but degradation, at least initially. Familiar places and species were gone. A once-forested landscape became wide open and sparsely vegetated. Land was disappearing rapidly. But as saltwater species established themselves in the emerging ecological regimes in the estuary, St. Bernard fishermen began enjoying abundant harvests of oysters, shrimp, and speckled trout in waterways closer to their marinas. The intensification of marine processes in the estuary has undermined the region's natural storm defenses, while at the time, rendered its fisheries more abundant and more easily accessed. Here we observe a crucial paradox in the ecological history of the region. Deteriorating salt and brackish marshlands provide ideal habitat for key commercial fisheries (Muth, 2014). These ecological regime shifts have thus produced political constituencies with divergent interests when it comes to implementing ecosystem-based strategies today.

Figure 11. Salt-tolerant *Baccharis hamifolia* sprouting in the dead stumps of the bald cypress tree. This location is only 4km from downtown New Orleans. Bayou Bienvenue passes just behind the tree line on the left. Source: Joshua Lewis.

To sum up, the infrastructural zones embedded in the swamps and marshes of Louisiana disrupt, transform, and produce environments. The most lasting and persistent of these transformations are ecological regime shifts, which in our case are driven by historical changes in the key variable of water salinity (Table 2). Being inherently embedded within socioecological relations, infrastructural zones have a range of implications for human livelihoods, circuits of trade and capital investment, and patterns of hazard exposure. The concentration of the negative aspects of these processes into a single territory can lead to the development of a socioecological cleavage with entrenched and persistent political divisions on water management policies. These cleavages can undermine attempts to achieve greater efficiency in the operation of infrastructural zones, and furthermore, complicate attempts to mitigate negative impacts or unintended effects as they emerge.

4. Reimagining and Enacting Ecosystems as Infrastructure: The River Remedy

We now move into the contemporary situation to analyze the conflict around the ecosystem-based infrastructural features of the Louisiana Coastal Master Plan, namely, river diversions. Diversions are created to introduce water and sediment from the Mississippi into nearby estuaries and basins. This plan has been supported since Katrina by a broad coalition of environmental groups, engineers, and increasingly, the local business community. The production of an infrastructural zone organized around the notion of restoring the delta's historical dynamics can be seen as a spatial and technological fix intended to reconcile the contradictions that emerged with the operation and maintenance of the infrastructural zones profiled in Section 3. But this time ecologists and their field of expertise (alongside engineering science as before) are more central

in structuring solutions and debates. However, despite their obvious appeal to a region traumatized by storm surges and concerned over rising seas, calls to “restore the delta” have become mired in controversy much like earlier infrastructural initiatives. The Save Louisiana Coalition (SLC), a group founded with the explicit intent of opposing river diversions, was formed in 2012. In this section we trace the emergence of this opposition and situate it in the historical findings described in Section 3.

4.1. – Historical Diversions: Possibilities and Problems with Ecological Infrastructure

While the massive diversion structures being considered for the Lower Mississippi River are only now being designed, other, smaller diversion projects have been attempted nearby. The politics surrounding these smaller structures provides further context for the projects currently under consideration.

By the mid 20th century, increasing salinities in the Breton Sound estuary in southern St. Bernard Parish (induced in part by Centroport’s shipping canals) worried state officials and some fishers that oyster production could be compromised without the freshening influence of the river’s floodwaters. The eastern oyster (*Crassostrea virginica*) requires a narrow salinity range to complete different phases in its lifecycle (Berrigan et al., 1991). It was thought by state and federal fisheries managers that the diversion of freshwater into the Breton estuary might support oyster production and other fisheries (Wilkins and Keithly, 2006). Oyster fishermen actually requested that freshwater be pumped into the estuary in 1955, and over the subsequent decades the Army Corps and the State of Louisiana developed a plan to build a small diversion of the river at Caernarvon, the same site that Army Corps dynamited in 1927. In 1991, the freshwater diversion came into operation, delivering up to 7,000 cubic feet per second (198 m³/s) of freshwater into the estuary when operational.

The environmental effects of Caernarvon and other diversions continue to be a source of controversy between proponents of the diversions in the 2012 master plan and the fishing industry (Figure 12). Owners of oyster leases in the Breton estuary filed a series of lawsuits in the 1990s that sought compensation for the displacement of salinities conducive to oyster harvesting from areas where a private leasing system applies to oyster harvesting, into lands comprised mostly of public oyster seeding grounds (Britton, 1996). While oyster productivity increased up to 300% in some areas in the estuary, it collapsed in areas closer to the Caernarvon diversion itself (Avenal vs. State of Louisiana, 2004). The Caernarvon case illustrates that while diversion of freshwater into estuaries may increase overall productivity, such increases can be unevenly distributed in space and thus produce winners and losers. This politicizes the process of coastal restoration and adds challenges for the management of existing river diversions and scaling up these small diversions into structures capable of conveying 10-35 times the sediment and freshwater volumes carried by the Caernarvon diversion. Coastal restoration advocates must persuade the public to support the adoption of a water management technique based on a prototype whose benefits have not

been entirely demonstrated nearly 30 years into their operation.

The Caernarvon diversion project has illustrated another potential problem associated with the diversion of river water into predominantly brackish and

Figure 12. The Davis Pond diversion, upstream from New Orleans, one of several small-scale diversion built by the state of Louisiana beginning in 1991 to prevent saltwater intrusion and produce freshwater habitat. The effects of these structures are a point of contention in the region. Source: Joshua Lewis.

saline marshes. Anti-diversion activists frequently invoke the project as an example of what sort of ecological blunders could be anticipated in a wider ranging and better-funded restoration agenda. While saltwater and brackish marsh plants can be killed and displaced by the introduction of freshwater, the freshwater marsh plants that take root in their place are in some cases less resilient to the impact of storm surges. This effect, noted by several coastal scientists, shows that the high nutrient loads from fertilizer runoff in the Mississippi (from upstream

farming activities) might encourage marsh plants to spread roots in a shallow formation to capture these suspended nutrients carried by river water. This shallow rooting depth, however, contributes to soil instability and can lead to the marsh plants uprooting when exposed to a tidal storm surge (Howes et al., 2010; Teal et al., 2012). A 2010 study examined the impact of Hurricane Katrina's storm surge on the freshwater marshes that emerged after the Caernarvon diversion was opened in 1991, finding that these freshwater marshes "are vulnerable to bulk erosion of the marsh platform during storms due to weaker soil strengths and reduced rooting depths" (Howes et al., 2010). Diversion opponents in St. Bernard frequently cite these observations (Figure 13), and even paid for a large billboard on the main interstate highway in downtown New Orleans that showed Katrina's impacts on the freshwater marshes near the Caernarvon freshwater diversion. In response, a coalition of environmental NGOs also bought advertisement space along the same stretch of highway, advocating for the construction of river diversions.

4.2. Articulating and Organizing a Counter-Narrative Against River Diversions

The Louisiana Coastal Master Plan was developed by the state of Louisiana's Coastal Protection and Restoration Authority (CPRA), which brought together a cadre of scientists, public officials, and other stakeholders. Initially put forward in 2007, the plan was significantly revised in 2012 and 2017 (Figure 1). The plan's geographical scope includes the entire Louisiana coastline, but the most significant interventions are slated for areas in the periphery of the city of New

Orleans and neighboring Jefferson Parish, which together account for nearly one million of the region's 1.2 million residents (US Census Bureau, 2010).

St. Bernard and Plaquemines Parishes, which lie downstream from the New Orleans metropolitan area, have only 67,000 residents between them. The most critical element of the plan, according to the State of Louisiana and its scientific partners, are large-scale river diversions, stating, "...sustainable restoration of

Figure 13: George Ricks of the Save Louisiana Coalition, at the Caernarvon River Diversion in lower St. Bernard Parish.
Source: *The St. Bernard News*, 23 September 2014.

our coast without sediment diversions is not possible" (CPRA, 2012: 106). While the plan received unanimous support from state legislators in 2012, resistance to major components of the plan has arisen, primarily amongst residents of St. Bernard Parish. Diversions are the chief infrastructural tool by which planners aim to prevent further catastrophic land loss in key estuaries. Another component of the plan that opponents have questioned is the restoration of coastal forests, which dominated much of the region prior to 1965. Diversion opponents have suggested an alternative strategy, which relies on the dredging and pumping of river-bottom sediments into eroding areas, quickly building land without introducing massive quantities of freshwater at the same time (Figure 14).

This is by far the most expensive land-building strategy in the coastal planning toolbox, and nearly half of the funds in the current plan are devoted to exactly this practice. River diversions are seen as a way to invest in fixed infrastructure to (cost effectively) build land over many decades, mimicking the river delta's historical dynamics and securing the long-term survivability of the region's population centers in the face of rising seas.

The debate would seem to highlight a tradeoff – a "restored" coast and "resilient" New Orleans implies a reorganization of the ecological regimes in its periphery. This could transform the saltwater fisheries on which many fishing communities depend. Some prominent coastal ecologists like Dr. Robert Twilley from Louisiana State University, admit that river diversions will displace saltwater species, but frame these inshore saltwater areas as "artificial fisheries" – the result of the human-induced saltwater intrusion that we documented in Section 3. Speaking to a local journalist in 2013, Twilley stated that "[t]he problem in Louisiana is we're addicted to salt... because that salt brings tremendous benefits in fisheries" (Snell, 2013). Even amongst fishers and hunters, there is disagreement over restoration strategies. Those who focus on fishing for freshwater species like bass and hunting waterfowl have expressed support for

diversions in many cases, whereas some fishers focusing on marine species have vehemently opposed them. In only a few years time, the broad consensus around “saving the coast” has become more politically complex than many might have anticipated.

Figure 14. SLC Sign outside of a marina in coastal St. Bernard Parish. January 2015. Source: Joshua Lewis.

This fragmentation can also be seen as splitting along temporal, as well as spatial lines. Coastal scientists, public officials in cities, and engineers often invoke the “deep time” perspective in developing their arguments for river diversions, in that the land of the delta was built over thousands of years and inferring that humans have effectively stopped that process. But this deep time perspective is typically insensitive to the class-based nature of infrastructure projects that we analyzed in Section 3. Diversion opponents, particularly those in St. Bernard Parish, highlight other disastrous water infrastructure projects implemented over past century, and propose dredging and pumping sediments as a sort of “quick fix” for the worst problems associated with coastal land loss.

It is from this context of division and conflict that we will follow the articulation of a counter-narrative across community meetings and public spaces (Ernstson and Sörlin 2009; Ernstson 2013), or counter-expertise. This means the weaving together of arguments and historical experiences into an alternative narrative of understanding the delta and its communities in opposition to the diversions. This narrative coalesced in 2010 and 2011, in particular during the planning phase of an ecosystem restoration plan designed to address the impacts of Centroport on the Lake Borgne estuary.

Since at least the 1960s, formal public hearings on water infrastructure projects have become focal social arenas through which opposition movements coalesce.

This is in some sense a product of the geographical expanse of the parish. Fishing communities extend out deep into the swamps and marshes, creating difficulties for regular meetings amongst interested parties. Public meetings provide a physical space where residents from throughout the region can come and voice their concerns, and where public officials in St. Bernard can go on record in their opposition to a project, validating circuits of patronage and reproducing political alliances at the local scale. Since the 1960s, St. Bernard citizens and public officials have spoken in near unison on hydrological issues - the product of a complex interplay between the actual material interests at stake and an orchestrated political drama that exhibits highly consistent features over time, and frequently referential of previous disputes and events in framing sequential political debates.

Our observations conducted at these public hearings demonstrate how St. Bernard residents have an acute awareness of how New Orleans interests tend to dominate regional water politics, and how St. Bernard has often been a "sacrificial zone" in times of high water. In one public hearing in 2010, following a presentation of the MRGO restoration plan by the Army Corps, the president of St. Bernard Parish, Craig Taffaro, rose to deliver a detailed presentation of his own. His presentation assessed the merits and shortcomings of the restoration plan at great length. Perhaps most notable was a phrase included on the bottom of each of the 30 slides in the presentation: "St. Bernard Parish is more than a barrier for the rest of metropolitan New Orleans." What became clear in this meeting was that many attendees and local officials from St. Bernard believed that the diversion of Mississippi River water into coastal wetlands would do damage to saltwater adapted ecosystems and thereby, the area's economy, and that the restoration of freshwater ecosystems in the Parish was an attempt by New Orleans-aligned interests to gain better flood protection at St. Bernard's expense. Taffaro advocated that the plan should rather focus on dredging sediments from the bottom of the Mississippi, and pumping the muddy slurry across great distances to "instantly" create new land, without compromising saltwater fisheries. Taffaro's comments called for residents to remain unified in opposing certain features of the plan, to honor a "...commitment to those who have stood at this juncture for decades before us, the commitment to those who died because of the neglect and coastalcide, demands that we push on."

The diversion of river water into the Parish's wetlands is ostensibly intended to rectify this "coastalcide," not re-produce an historical environmental injustice. Yet, over a century of contentious politics and human suffering has yielded intense suspicion that any large-scale transformation of the ecosystems in New Orleans' periphery typically benefits elite economic actors in New Orleans striving to secure their critical infrastructure and accumulate capital, while off-loading environmental hazards and ecological uncertainty to peripheral communities with less political and economic power. This is especially true with regard to the diversion of the Mississippi River through St. Bernard. While the river diversion being considered in 2011 meeting planned to only convey 5,000 cubic feet per second ($142 \text{ m}^3/\text{s}$) of water during a "spring pulse" - the Louisiana

Coastal Master Plan, released just a year later, proposed the construction of multiple river diversions in the area, one with a capacity of up to 250,000 cubic feet per second (c. $7 \text{ km}^3/\text{s}$) – a third of the Mississippi's average flow.

4.3. Memorializing Historical Experiences: Solidifying a Cleavage

As part of the Louisiana Coastal Master Plan, the MRGO Ecosystem Restoration plan includes a river diversion at the same location as the Port had planned its failed connecting lock and channel in the 1960s. This contestation in particular helps to deepen our understanding of the fault lines of the socioecological cleavage we are tracing through the emergence of the counter-narrative.

In a series of public meetings in 2011, diversion opponents attempted to draw connections between the two projects. Audience members shouted of the diversion, "Its another MRGO!" and "Its gonna kill us!" (USACE, 2011). Invoking the same existential urgency in relation to the diversion projects is seen by some observers outside of St. Bernard as disingenuous and hyperbolic. However, it resonates with a wider historical sentiment of again being on the negative end of large-scale projects directed by New Orleans interests. Similar public comments were uttered against the MRGO project decades earlier — and on the banks of the MRGO in Shell Beach there is a memorial to St. Bernard's Katrina fatalities (Figure 14). Speakers at meetings often also framed the Army Corps, the diversion project's manager, as untrustworthy partners, citing their dismal track record in the area, and their historical alignment with New Orleans business interests. Said one commenter: "Do you know why MRGO was put there originally? For some rich landowners in Eastern New Orleans that wanted build a boat terminal in there" (USACE, 2011). Another resident of a fishing community also compared the diversion plans to earlier water infrastructure projects through the parish, and voiced concerns over the ecological transformations that might accompany the new interventions: "The people of St. Bernard need to stand up and fight this project... you're going to annihilate a recreational [fishing] industry, a commercial industry, and all you're going to be able to catch out there is catfish... What are we going to do with that? Where did all the speckled trout and red fish go?" (USACE 2011) Beyond the fishing impacts, then Parish president Taffaro made reference to earlier attempts to build water infrastructure through the area, stating that "to dig out another channel again divides our parish geographically. It divides us physically and it divides us culturally."

This mobilization represented a galvanized civic moment, at least locally. As opposition to the diversions became more organized following the release of the 2012 Coastal Master Plan, the St. Bernard Parish council voted unanimously in 2013 to ban the construction of any new river diversions in the parish, demonstrating the development of the cleavage at a representational democratic level. This "ban" has no firm legal standing, but reflects a 50-year history of the parish council going on the record in opposition to major water infrastructure projects.

4.4. Diversion Opponents in Action: Battle for the Bayou Bash

Beyond the public hearings around relevant projects, internal meetings and fundraisers are also important to instigate collective action. Internal meetings enable the recruitment of new support and to solidify the resolve of those already mobilized. By observing a fundraising event organized by the Save Louisiana Coalition in 2013, we are reminded how the historical construction of infrastructural zones and the diversion of floodwaters through St. Bernard are perceived and characterized to mobilize opposition to river diversions today.

Figure 15. Memorial to St. Bernard residents who died during Katrina. The memorial sits along the banks of the MRGO channel. Source: Joshua Lewis.

The event was billed as the “Battle for Bayou Bash,” a dinner, musical performance, and rally hosted at the St. Bernard Parish Civic Center. For a \$25 entrance fee, those attending could eat a variety of Louisiana seafood dishes prepared by local restaurants, including some well known New Orleans establishments like Galatoire’s. Prominent oyster distributors were also present. At the event’s peak, perhaps 200 people were in attendance. George Ricks, a recreational boat captain, a founder of the Save Louisiana Coalition, and the evening’s master of ceremonies, took to the stage and described the predicament that brought the various groups together. Ricks explained that “St. Bernard Parish has been through a lot, Katrina, BP [oil spill], MRGO. St. Bernard Parish has become something like a whipping boy for the rest of the state of Louisiana.” Ricks then introduced a video that featured a series of images of life in coastal Louisiana communities, with a narration called “So God Made a Fisherman,” celebrating the role of fishermen in community life, as providers of food, and the bearers of heritage and history. After the video concluded, Ricks himself sang lead vocals on a rendition of “Louisiana 1927,” a song written by Randy Newman about the devastation wrought by the great Mississippi River flood of 1927, when federal authorities dynamited the levee at Caernarvon. The song’s chorus goes

“Louisiana, they’re trying to wash us away” - on the final refrain Ricks added, “but we’re not gonna let that happen!”

Later, Ricks returned to stage and invited St. Bernard Parish President David Peralta to join him. Peralta explained that the St. Bernard Parish government was fully dedicated to preventing the construction of new river diversions in the parish. Peralta stated that the seafood and fishing industries comprised 20% of the parish economy. He claimed that the parish council, usually a divided body, had found consensus easily on their opposition to new diversions. “Many of you know that I was police officer for 33 years, and I’ve never been to jail,” said Peralta, “but the day they try to cut the levee, I will go to jail to stop them.” Ricks invited key supporters of the SLC up to the stage, which included the heads of many fishing and seafood commercial associations, like the Louisiana Shrimpers Association and the United Commercial Fisherman’s Association. He highlighted the support of certain scientific advisors, including one from NASA who had written about the problems with the Caernarvon diversion. Clint Guidry of the Louisiana Shrimpers Association remarked that it was rare to have all the various sectors of the fishing industry aligned behind one issue and organization. Guidry stated that “if we don’t fight for our cultures and way of life, we’re done... if we don’t stay together we won’t be here very long,” echoing Ricks’s musical performance. Ricks took the microphone to wrap up the event, explaining that “its just wrong that state bureaucrats in Baton Rouge¹⁵ can push a button on a computer and decide what our lives are going to be. Its all of it, the fisheries, our heritage, but its also the friggin’ injustice of it all.”

How anti-diversion activists narrate their movement, and the historical conditions that gave rise to it, highlight how longstanding cleavages in the landscape and society between the urban core in New Orleans and the periphery in St. Bernard have developed and influence the contemporary politics around river diversions and coastal restoration. In the next section we turn towards a discussion of how scientists and state agencies have responded to the emergence of the SLC and opposition to river diversions.

4.5. The Controversy Clarified Through Public Dispute

The media coverage of the rambunctious public meetings began putting pressure on local officials to oppose the diversion projects. This compelled state coastal planners and environmental groups to “come out” publicly in arguing for the creation of river diversions. This is a crucial turning point in the controversy, which effectively politicized river diversions and made available alternative interpretations of the delta ecosystem. A striking example that outlines the contours of this politicization was a full-page advertisement that appeared in many newspapers and media outlets in Louisiana in 2015. Signed by nearly 30 prominent wetlands scientists and ecosystem managers and paid for by a

¹⁵ Baton Rouge is the capital of the State of Louisiana.

coalition of environmental organizations, the letter stated the case for building large-scale river diversions. It began:

What if you knew about impending disaster for one of the world's greatest wildlife and fisheries treasures and you knew there was something that could be done to minimize it? The treasure being lost is Louisiana's coastal wetlands, which arguably hold the most abundant concentration of fish and wildlife in America. This catastrophic loss is happening and will get worse as long as Louisiana continues its present course. An objective examination of all of our coast and all who depend upon it, now and in the future, reveals that a solution is available: manage the Mississippi River to build new wetlands and create a range of freshwater to saltwater habitats that will provide a home for Louisiana's fish and wildlife for years, decades, and even centuries into the future. (Bahr et al. 2015)

Without the preceding years' growth of a vocal opposition to diversions, it is unlikely that this letter would have been drafted or resources expended on its wide circulation. The letter goes on to reference this opposition specifically, and its characterization is revealing:

Louisiana should not allow exaggerations and speculations regarding the effects of diversions on oysters, shrimp, speckled trout, etc. to prevent action. In many areas where previous generations grazed cattle and hunted ducks, and alligators, commercial and recreational fishermen now harvest oysters, shrimp and speckled trout because of saltwater intrusion. (Bahr et al., 2015)

While noting the historical transformations of the coast, the letter admits that diversions will have impacts on fisheries, but claims that they won't be destroyed, but displaced. As the authors state, "diversions will not destroy saltwater fisheries but instead will immediately push them farther from some parts of our coast. Unfortunately this will economically harm some commercial fishermen" (Bahr et al, 2015).

In response, the Save Louisiana Coalition released a letter of its own rebutting some of the claims made by scientists. The letter stated in part that:

Those whose livelihoods depend on the seafood industry and ancillary businesses are often painted as the enemy of restoration and concerned only for their "parochial" interests. This is not true. Yes, they may have more concern than those whose personal livelihoods don't depend on the estuaries, but they are not the enemy and it is not just "fishermen" who are voicing major concerns about these diversions. What that letter failed to mention is that several federal agencies, Parish Governments, Port Authorities, and even some of the State's own task forces have officially lodged their concerns... The desire for a consensus in support of diversions seems to now be more about maintaining political clout for funding than a realistic attempt to evaluate the coastal situation. We all would like to see our wetlands restored and hope for a magic bullet to do it, but considering the reality of sea level rise, geological subsidence, river dynamics and many natural and man-induced liabilities, we need more critical and independent thinking in consideration of these huge and costly projects. (SLC, 2015)

Groups like the SLC who oppose large-scale river diversions have produced a

public scrutiny and a level of nuance into the public conversation around coastal restoration that would be unlikely to occur otherwise, for instance as here, to insist of the deep uncertainties that large-scale interventions carry. This could potentially have major impacts on how planning will be carried out since, if taken seriously, it means that a wider cast of actors and associated ways of knowing the delta will need to be acknowledged up front in producing planning and action (Whatmore 2009). Such radical re-imaginings of planning practice might still not be there, but as we start wrapping up the empirical account, it's important to acknowledge that one effect of the counter-narrative has been the expansion and creation of more public arenas for deliberation.

The "Expert Panel on Diversion Planning and Implementation" is one such example. Convened by the State of Louisiana's Coastal Restoration Authority from 2013, it comprises of 12 scientists and environmental planning specialists drawn from universities and agencies inside and outside of Louisiana. The panel is charged by the State of Louisiana to "provide technical input, review and guidance as plans are refined on diverting freshwater and sediment from the Mississippi and Atchafalaya rivers into adjacent estuarine basins to build, maintain and sustain coastal wetlands" (CPRA, 2015). The concept of "uncertainty" permeates the reports developed by the expert panel on diversions, due to the "complexity of the science and engineering associated with the design and operation of major freshwater and sediment diversions, and that there are no analogues of existing sediment diversions at an appropriate scale, it became clear that uncertainty was a highly relevant and pressing topic for consideration" (CPRA, 2015). The expert panel's meetings include public hearing in which members of the public can attend and comment on the diversion planning process. As has been the case in so many public meetings on the construction of water infrastructures in St. Bernard Parish, many fishermen and other residents attend these hearings to voice their concerns, which the expert panel has summarized into seven categories:¹⁶

1. Negative fisheries impacts (displacement of fisheries, fisheries kills, loss of livelihoods)
2. Doubts as to the potential of newly built land to reduce storm surge
3. Prefer smaller diversions instead of the larger planned diversions
4. Prefer dredging over diversion projects
5. Flooding concerns and increased water levels
6. Concerns regarding nutrients and invasive species from Mississippi River water
7. Large diversions take too long to build land

For scientists and environmental groups, the Mississippi Delta cannot be sustained without the implementation of massive freshwater and sediment diversions. This is no doubt true for many locations in the deltaic plain, but such plans necessarily come with high levels of uncertainty that undermines commonplace authority of science and technical expertise. One response to this from the scientific community has been to work closely with the State of

¹⁶ Slightly modified by the authors for clarity.

Louisiana to develop novel and interdisciplinary research environments devoted to the design and management of coastal restoration projects. Much of this work is still focused on the development of computer models that try to predict how diversions will effect ecological systems in different contexts and use these to explore impacts on nearby communities and livelihoods. While a common concern among scientists and environmentalists is that the planning and design of these initiatives must be done with technical precision based on engineering and natural science, with so much at stake there is also a growing concern that planning needs to be done with greater political transparency than during previous decades. In our last section we will focus on pulling out key lessons that we believe our case study brings in relation to planning practice in Louisiana and beyond.

5. Discussion: Implications for Planning

A strong theme in our account is how infrastructure, urban-regional politics, and ecological dynamics converge over time to generate distinctive political situations and environmental justice dilemmas. The historical narrative foregrounds the extant tensions between institutional power centered in New Orleans, and the coastal communities and ecosystems around the city. For over a century, the periphery of New Orleans has been reorganized to serve the goals of flood protection and capital accumulation. Here in our discussion we will focus on three key implications that we believe our case study brings to the practice of planning in Louisiana, and more generally to discussions of planning theory when ecological and sociopolitical dynamics are tightly wedded together. We first elaborate on how *socioecological cleavages* relate to certain forms of infrastructure violence, which problematizes the relation between planning and its bias as a discourse of the core. We then move to how planning practice could more explicitly deal with *knowledge controversies* that are inherent to such large-scale planning. And finally, we focus on how various forms of politicization can challenge asymmetrical power relations as a prerequisite to help democratize the administration of planning, expanding it to be viewed practically and theoretically as a much wider activity than simply the development of expert-led master plans followed by stakeholder 'dialogues'.

Together these three points help to scrutinize current policy discourses around coastal planning and urban resilience where we emphasize that "ecosystem-based" initiatives are not immune from or unaccountable to earlier conflicts over infrastructural zones and environmental management. In contrast, such conflicts have become entrenched in how ecosystems and societies operate together in a path-dependent fashion, which needs to be fully recognized in any planning practice aimed at restoring (or changing) the functioning of large-scale ecosystems. This partly lies in ensuring that just political processes and just outcomes are achieved for groups marginalized and placed at risk by previous investments in infrastructure. If managers fail to acknowledge these historical dynamics and injustices, opponents have demonstrated that they are capable of slowing down and obstructing the implementation of large-scale water

infrastructures. As sea-level rise projections continue to alarm coastal communities globally, the politics around river diversions in Louisiana reveal the sort of tensions and potential impediments for large-scale coastal infrastructure planning moving forward.

5.1. Socioecological Cleavages and Infrastructural Violence

Social inequality is inscribed in infrastructure networks, often in complex and historical ways and as effects of core-periphery situations like those we have studied here. One way to understand these composite effects is “infrastructural violence,” a concept that bridges burgeoning interest among anthropologists, geographers, and urban scholars in tracing how uneven distribution of benefits and hazards amongst social groups arises as material infrastructure connects certain spaces and disconnects others in contemporary urbanization (Anand 2012; Rodgers & O’Neill 2012; Graham & McFarlane 2014).¹⁷ Drawing on Johan Galtung and Paul Farmer, Rodgers and O’Neil develop infrastructure violence in a 2012 article as intimately connected to a wider social order that both exerts and hides violence:

To a certain extent, it could be argued that infrastructure constitutes an often-ignored material channel for what is regularly referred to as ‘structural violence’, which Paul Farmer (2004: 307) has defined as ‘violence exerted systemically – that is, indirectly – by everyone who belongs to a certain social order’... Once considered from the vantage of widely constituted social structures, violence becomes thinkable as an effect of what Farmer (2004: 307) calls a ‘social machinery of oppression’: complex processes of production whose outcomes are objectionable, in which all members of society are implicated and yet whose effects are ostensibly nobody’s fault. (Rodgers and O’Neil 2012: 404)

The literature on infrastructural violence has pointed out that the power in question is not only material, but also symbolic. This plays into the political dynamics of these situations in two ways. From the viewpoint of the dominant center, peripheral communities are viewed or casted as clinging to their historical, cultural and social traditions, as being quaint and backwards. Elite actors in the center, as expressed by Zarycki (2007), “frequently have serious problems with grasping the very idea of the multi-dimensionality of the periphery’s social world” (p. 128), and “are simply unable to see this aspect of symbolic violence in their own behaviours, when they treat the centre’s cultural values as universal ones, and their transmission to the periphery – as beneficial attempts at ‘modernisation’” (p. 125). For large-scale planning, an activity historically shaped by the core and elite groups, this becomes a problem where planners and experts might think they are promoting what is ‘best for all,’ that ‘everybody wins,’ because they cannot or they choose not to recognize their own biased views. This boils down to a central problem for planning practice in

¹⁷ The notion of “infrastructural violence” bridges burgeoning interest by scholars in tracing how social inequality is inscribed in infrastructure networks (Rabinow, 2003; Star, 1999; Monstadt, 2009; Graham & Marvin 2001; Graham & McFarlane 2014) with the concept of “structural violence,” as introduced by Johan Galtung (1969) and elaborated by Paul Farmer (1996; 2004).

grappling with its own bias. Speaking clearly into this impasse, and something we will develop further below, Vanessa Watson (2003) has developed the useful concept of "conflicting rationalities". Rather than a practice shaped by consensus-building and universalized ideas and values, most often formed and shaped by the center's institutions and discourses, planning should fully acknowledge profound disagreements and radically different ways of knowing and recast planning as a practice "grounded in a deep understanding of contextual difference" and relational ways of knowing (Watson 2003: 405, 406). This poses, we mean, critical political, ethical, discursive and organizational challenges for planning practice and the implementation of ecosystem-based infrastructures. While materially seeking to rework urban peripheries, it also implies a re-working of the core's understanding of itself, moderating elite interests and public opinion.

The canals and swamplands of Louisiana complicate matters further. The discussions on infrastructural violence have so far centered on service delivery and inequalities related to engineered infrastructures of transport, water and sewage. Our study highlights the growing challenge to plan for infrastructure in the uncertain context of urbanized coastlines, deltas and complex, dynamic ecosystems. In Louisiana a pattern emerged where more 'peripheral groups' in the delta were pitted against an 'urban core', a split not simply based on spatial distance or network connectivity, but on ecological regime shifts. In the context of planning this has far-reaching consequences since unequal outcomes emerge from the intersection of infrastructural zones and ecological regime shifts. It is the unpredictable path dependencies associated with infrastructural zones, ecosystems, and territorial marginalization that became entrenched in the Louisiana landscape and through which material and symbolic forms of violence played out. One lesson for large-scale planning efforts might be to much earlier and explicitly fund and promote autonomous interdisciplinary research groups that can carry out situated, textured and historical ecological studies to sensitize the planning situation to multiple ways of knowing as part of a broader notion of democratic planning. Some literature points to this need.

Scholarship on climate change adaptation has for some time discussed how longer time perspectives make visible politically charged issues of equity and justice (Adger, 1999; Adger et al., 2005; Paavola and Adger, 2006; Thomas and Twyman, 2005; Tompkins and Adger, 2004; Wolf et al., 2010). While we would like to see more detailed historical approaches within this rapidly growing field, review articles demonstrate that benefits and risks associated with substantive 'adaptation strategies' along developed coastlines are likely to be unevenly distributed both globally and within particular settings (Adger, 1999, 2004; Paavola and Adger, 2006; Thomas and Twyman, 2005). We are thus in full agreement with Adger's (2003) remarks, that effects of climate change are "spatially and socially differentiated," and these changes "will be felt particularly by resource-dependent communities through a multitude of primary and secondary effects cascading through natural and social systems" (387). In relation to large-scale water control infrastructures designed as adaptation

measures, Tompkins and Adger (2004) argue that rather than trying to hide away, planning practice should highlight “technological solutions that have had detrimental environmental or social impacts to excluded groups in the past” (10). To address social justice both procedurally and programmatically is held as critical. As phrased by Paavola and Adger (2006: 606):

...social justice is an integral part of environmental governance which is best addressed explicitly and directly. Fears that doing so may escalate environmental conflicts are common but largely unwarranted. Quite the contrary, keeping social justice off the negotiating table denies the relevance and legitimacy of vulnerable actors’ concerns and interests.

We could add here that if not tackled directly, the investments in planning and implementation might later be undone and wasted as peripheral groups mobilize to redirect or obstruct large-scale infrastructure and ecosystem management programs. While the adoption and implementation of infrastructure planning framed explicitly as climate adaptation is a rather recent discursive shift, the situated socioecological contexts that these projects purpose to re-work carry longer historical path dependencies that generate political and material constraints around climate adaptation measures. Our historical and situated account of the formation of socioecological cleavages brings greater empirical precision and analytical clarity to these ongoing discussions.

5.2. Knowledge Politics and the Problems of Resilience-Based Coastal Planning

The deep uncertainties pervading large-scale infrastructure and ecosystem-based strategies shape the politics associated with them. This surfaces as discursive struggles of ‘who is in the know’ or who has legitimacy to speak technically or morally of what to do. While we in Section 3 analyzed the articulation of a counter-narrative to ‘coastal restoration’ by St. Bernard Parish residents, it is equally important to ask what organizes the planning and expert narratives of the core. This discourse is epitomized by the expert-led Louisiana Coastal Master Plan from 2012 (CPRA, 2012). This plan interestingly shows an overarching shift towards the dependence of ecological expertise in comparison to previous large-scale infrastructure interventions that dealt with drainage from 1920s to 1970s, which were grounded firmly in engineering science and practice. Centering ecological expertise, the discourse of “urban resilience” has emerged as an organizing concept within regional water planning, still of course highly reliant on engineering expertise to carry out material interventions. It is important to recognize that this has had positive effects in expanding the range of expertise. Certainly, if scientific ecological knowledge had been acknowledged in earlier planning phases around Centroport, some of the worst ecological effects of the infrastructural interventions in the region might have been avoided.

On the other hand, the resilience framework, both as a research program and policy framing, is underdeveloped with regard to historical and geographical situatedness and it has been critiqued of eschewing asymmetrical power relations and drawing overly on a functionalist view of knowledge (Nadasdy

2007; Evans 2011; Ernstson 2013). This is illustrated for instance by Folke and colleagues (2005: 441) in a central paper when they argue, without acknowledging underlying asymmetrical power relations, for “the potential in combining local knowledge systems with scientific knowledge to cope with change in resource and ecosystem management.”¹⁸ Here knowledge comes as neat ‘packages’ (scientific, local, traditional, etc.) that can be added to ‘complement’ each other, sidelining knowledge controversies and building on an assumption that a common interest for the management of the ‘social-ecological system’ can be forged (Nadasdy 2007). Lodged within consensual assumptions that seek to avoid disagreements (Hornborg 2009; Kaika 2017), such a functionalist view of knowledge risks gravely misreading knowledge controversies of the sort we find in center-periphery situations. Indeed, as we saw in Section 3, scientists, politicians and environmental organizations seemed to have been looking to secure consensus and a techno-managerial solution by relying on experts and particular environmental organizations. However, by using established democratic practices, the St. Bernard residents and SLC activists successfully disrupted the smoothness of planning and forced authorities to “slow down” their reasoning (Stengers 2005). Through their counter-narrative, the delta became more than a system to be managed, more than a buffer, fishery, or wild-life habitat — but became intimately viewed as part of a way of life, troubling the whole idea that the delta could be ‘functional’. Somewhat unexpectedly this means that while the conflict is intensely about material things, from where diversions, flood walls, and fish species are to be located, the conflict should (also) be profoundly understood as being about cultural and knowledge politics. Put simply, the ability to ‘claim to be in the know’ is central to understanding the conflict and what might happen. Arriving at this impasse, however, could also indicate constructive ways forward.

In her own studies of flooding controversies in England, Whatmore (2009: 587) argues that to “slow down” thinking is crucial for effective public questioning of expertise. This in turn she argues has direct relation to what is later done in terms of material investments, and in re-distributing expertise across a wider cast of actors:

Expert knowledge claims, and the technologies through which these become hardwired into the working practices of industry and government, manifest themselves in the products and policies we live with and the sociomaterial environments we inhabit. Controversies act as force fields in which such expertise becomes enmeshed with, and redistributed through, ‘an ever-growing, ever-more-varied cast of characters’ (Callon, 1998: 260) sufficiently affected by what is at issue to want to participate in collectively mapping it into knowledge and, thereby, into its social ordering.

¹⁸ There has been extensions of how knowledge has been treated in social-ecological systems theory, for instance through anthropological and indigenous knowledge frameworks (Berkes, 2012) as ‘communities of practice’ (Barthel et al., 2010), as embedded in social networks across scales (Ernstson et al., 2010), and as part of social learning (Crona et al., 2011; Reed et al., 2010). However, these developments have mainly been organized—in particular when taken to the policy level—under the frame of a functional view of knowledge as developed in the main text (Ernstson, 2013; Evans, 2011).

A possible lesson for planning theory is to look at case studies of longer processes of public engagement between experts and residents, what Whatmore (2009; Whatmore et al. 2011; Whatmore and Landström 2011) has coined 'competency groups,' and ask how this type of civic-public formations could more explicitly grapple with socioecological cleavages and knowledge controversies. While 'competency groups' might not resolve deeper-seated political problems, for which wider democratic practices and public disputes are needed (see below), they could produce a richer and more textured landscape of knowledge in which planning practice can be situated. Rather than facing an already worked out coastal master plan, which in its completeness tend to erase "all the uncertainties and provisos [from] the process of scientific knowledge production," competency groups, as Whatmore (2009: 595) continues, represent a "civic apparatus" to slow down thinking, open up various ways of knowing and show publicly how intermediate stages of knowledge production are intimately attached to uncertainties and controversies. This aims to "redistribute expertise across the 'scientific'/'vernacular' divide" (Whatmore 2009: 595). In Louisiana, one could imagine 10-12 scientists and residents meeting bi-monthly for say 12-18 months as an experiment in knowledge production, which could help the wider polity of Louisiana to dig deeper into what is known of the delta, but also *how* the wide-stretching delta is known—its dynamics, economic and cultural importance. Such processes could anticipate, contest and possibly shape any serious consideration of a state-led planning agenda, which ultimately seems very much needed in some form to handle future sea-level rise, increase hurricane activity and so on.

While the suggestion of 'competency groups' is an interesting one, more experimental research and scholarly debates are needed to understand how they could be developed and 'scaled up' for the larger-scale ecosystems that are of concern here, in particular how they might be instituted within wider democratic institutions. Positive signs nonetheless lie in how universities and coastal planning agencies in Louisiana have recently initiated wider civic meetings. As we will turn to next however, it is crucial to remember that this only happened after the disruptive effect that the counter-narrative had on certain aspects of the Coastal Master Plan. This raises questions around the role of more fundamental aspects of democratic decision-making.

5.3 Beyond Knowledge: Democratic Practices and The Political

For planning to change its course, political and properly democratic mediation is necessary. Many think about planning narrowly, as something carried out by 'planners.' But our account shows that a much wider set of actors, spaces and forums are involved in planning's real administration and possible democratization. Throughout the historical account, we see how expert plans again and again run up against a mobilized civil society that in all its beauty and ugliness hurls stones into planning's machinery, demanding change. This goes beyond simply "slowing down" thinking and entails the use of democratic

practices such as sit-ins, protests, town hall meetings and so on to shift on whose terms problems can be framed. Our elaboration on 'competency groups' must consequently be couched within a wider understanding of asymmetric power relations, which is lacking from Whatmore's (2009) theorization, as there is indeed a real risk that such gatherings of experts and laypersons become transformed or co-opted into quite ordinary stakeholder dialogues or adaptive co-management processes. While Whatmore's theorization is certainly more elaborated and sensitive to constructionist ideas of knowledge, she seems overly invested in knowledge production as the key driver of sociomaterial change, when we mean it is simply one among other forms of power.

Again Watson's (2003) idea of "conflicting rationalities" could provide a bridge out of this impasse. In highly conflictual situations, where social groups have vastly different historical experiences of society, she critiques deliberative Habermasian-inspired processes since they are "unable to comprehend the very real clash of rationalities [that] so frequently occur when a plan or development project touches the lives and livelihoods of households and communities." (Watson 2003: 396). The real problem she identifies in deliberative modes of planning, and thus how we see that asymmetrical power relations might bias and stifle 'competency groups,' lies in how the dominant, hegemonic socialized order is never questioned. While supposedly open toward a multifaceted society, there is still a carefully hidden order in deliberative modes of planning that makes certain voices appear illegitimate from the outset, and only minor changes to this order can be allowed, which also resonates with our earlier discussion of infrastructural violence. Simply put, Watson means that planning needs to radically acknowledge deep differences and conflicts as a starting point, and not what should be hidden.

This in turn, and finally, brings home that planning practice cannot be viewed as an objective or neutral activity, accompanied with signifiers like 'everybody wins'. Rather, planning should be seen as inherently political, operating through a wider set of democratic practices, which ultimately might produce winners and losers. This expands planning to importantly be thought with how Rancière (2010) has conceptualized democratic practices as the ability of those who are not counted and have no voice, to rupture a given normalized order and force a new arrangement of who counts as equals. The collective that made their voices heard from the periphery of the Mississippi should consequently not simply be labeled "stakeholders," something nominally defined and "selected" by an external party, typically by authorities, consultants or experts. Rather, these voices should properly be viewed as a *political community*, an entity in Rancière's terminology that has rendered itself visible and audible to contest decisions and political processes in which it was not invited to take part. As a collective they forced themselves into the field of power, to interrupt and influence. Thus, when we take in the wider image of what Farmer (2004: 307) above called the "social machinery of oppression" in the form of infrastructural violence, 'competency groups' as a process within planning seem insufficient. Rather a rupture of a normalized order of reason and reasoning, an acknowledgment of conflicting

rationalities had to occur in order to contest hegemonic categories of the center. As Zarycki (2007: 125) alluded to above, the center needs to be taught about their own ignorance in how they view the periphery, which was made possible through petitions, sit-ins, protests, and anti-violent demonstrations.

This sequence, *rupture* through democratic practices (Rancière 2010), acknowledgement of *conflicting rationalities* as a starting point for planning (Watson 2009), followed by the “slowing down” of thinking through constructionist knowledge production via *competency groups* (Whatmore 2009), might hold some promise for thinking through the role of planning in relation to large-scale ecological interventions and asymmetrical power relations. Indeed, the political community, here consisting of St. Bernard Parish and SLC activists and members, came into being through utilizing the democratic forums at hand — and articulated a potent counter-narrative that stretched back a century. Most certainly, large-scale interventions of various forms are needed in Louisiana for the region’s survival. A more geographically nuanced and historically informed approach to the delta’s transformation might bring about a more just and perhaps even a more expedient coastal restoration praxis.

5. Conclusion

While widely touted by scientists and policymakers, planning for resilience along urbanized coasts implies a more-than-urban project. Epitomizing ambitious spatial planning agendas, these proposals generate conflicts over design and implementation, regardless of how imperative a project may seem for the future viability of coastal cities and communities. Indeed, if the principal benefits of ecosystem-based flood protection are devised to benefit urban residents and firms in the form of flood protection and risk reduction, the spaces and ecosystems enrolled to create these services are in many cases peri-urban, rural, or remote coastal landscapes. These initiatives could therefore be forced to confront long-standing tensions and environmental inequalities between urban cores and their coastal peripheries.

Our historical case study from Louisiana demonstrates how such tensions emerged through 20th century urban water infrastructure initiatives. Elite actors mobilized peri-urban space to generate capital accumulation and infrastructural services for urban interests in the ‘core,’ which lead to disputes and mobilization amongst communities in the periphery. While more historical case studies are needed, we posit that large-scale ecosystem restoration programs will necessarily confront not only the prospect of more hazardous hydrologies, but also the historical legacies, material and political, of water infrastructures and land use policies at the urban periphery. In these spaces, where vulnerability and hazard exposure has long been off-loaded from urban environments, marginalized communities will need to develop political strategies to protect their interests, as large-scale ecological changes are being proposed and implemented in their immediate environs. How democracies like that of Louisiana and the USA are to handle such disagreements in the face of deep

uncertainty requires more research across different contexts.

These are difficult issues, laden with both ambiguity and urgency, but nonetheless we hope that our case study and its associated framework can raise awareness and curiosity among planners and the broader profession to seek out in their own planning context how infrastructure, ecosystems, and planning disputes might be *historically intertwined*. As argued by Watson (2003):

Planning research needs to return to the concrete, to the empirical and to case research, not as a mindless return to empiricism, but as a way of gaining a better understanding of the nature of difference, and generating ideas and propositions which can more adequately inform practice.

In this sense our case study is full of possibilities for scholars, planners, ecologists – and activists, to translate and learn from Louisiana how deep-time and large-scale ecological dynamics intersect and become part of cultural, economic and planning politics.

What is clear is that ‘resilience thinking,’ if wedded to a policy-discourse where ‘everybody wins’ (which effectively distances it from its more nuanced non-equilibrium ecological origins), severely downplays what is at stake. The alternative, which the public controversy in Louisiana has demonstrated, is to acknowledge that resistance and conflict can be generative and constructive. They embed environments in historical relations, politicizing environments and opening them up for what our democracies were set up to handle – dissensus and discontent. In this regard, our case study shows with all clarity that in the context of global climate change, much is at stake in Louisiana and across the world’s densely populated coastal regions. In certain communities and habitats, significant territories and indeed entire communities and cultural worlds could come to be submerged by rising seas or destroyed by storm surges. The current policy trajectory for peri-urban coastal areas that relies upon ecosystem-based resilience strategies will be bound up in deeply fraught issues of land rights, sense of place, community displacement, and resettlement (Dalbom et al., 2014). The wider questions on what to do, by whom, and where, requires not only more research, but also democratic institutional innovation.

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References

- AAPA, 2013, World Port Rankings, American Association of Port Associations.
- Adger, W. N., 1999, Social vulnerability to climate change and extremes in coastal Vietnam, *World development* 27(2):249-269.
- Adger, W.N., 2003. Social capital, collective action, and adaptation to climate change. *Economic geography*, 79(4), pp.387-404.
- Adger, W. N., 2004, The right to keep cold, *Environment and Planning A* 36(10):1711-1715.
- Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., Rockström, J., 2005, Social-ecological resilience to coastal disasters, *Science (New York, N.Y.)* 309(5737):1036-9.
- Ahern, J., 2007, Green infrastructure for cities : The spatial dimension.
- Allison, H. E., Hobbs, R. J., 2004, Resilience, adaptive capacity, and the lock-in trap of the Western Australian agricultural region, *Ecology and society* 9(1).
- Anand, N., 2012, Municipal disconnect: On abject water and its urban infrastructures, *Ethnography* 13(4):487-509.
- Austin, D., Marks, B., McClain, K., McGuire, T., McMahan, B., Phaneuf, V., Prakash, P., Rogers, B., Ware, C., Whalen, J., 2014, Offshore Oil and Deepwater Horizon: Social Effects on Gulf Coast Communities Volume I, U.S. Department of the Interior Gulf of Mexico OCS Region Bureau of Ocean Energy Management, New Orleans, LA.
- Azcona, B. L., 2006, The razing tide of the Port of New Orleans: Power, ideology, economic growth and the destruction of community, *Social thought & research*:69-109.
- Bahr, L., et al. 2015. An open letter to the citizens of Louisiana. Available from <http://www.mississippiriverdelta.org/files/2015/05/AnOpenLettertotheCitizensofLouisiana.pdf>.
- Barbier, E. B., Georgiou, I. Y., Enchelmeier, B., Reed, D. J., 2013, The value of wetlands in protecting southeast Louisiana from hurricane storm surges, *PloS one*
- Barry, A., 2006. Technological zones. *European journal of social theory*, 9(2), pp.239-253.
- Barry, J.M., 2007. *Rising tide: The great Mississippi flood of 1927 and how it changed America*. New York:Simon and Schuster.
- Barthel, S., Folke, C., Colding, J., 2010, Social-ecological memory in urban gardens: Retaining the capacity for management of ecosystem services, *Global Environmental Change* 20(2):255-265.
- Batker, D., Mack, S. K., Sklar, F. H., Nuttle, W. K., Kelly, M. E., Freeman, A. M., 2014, The importance of Mississippi delta restoration on the local and national economies, in: *Perspectives on the Restoration of the Mississippi Delta*, Springer, pp. 141-153.
- Bea, R., Cobos-Roa, D., 2008, Failure of the I-wall flood protection structures at the New Orleans Lower 9th Ward during hurricane Katrina, *Electronic Journal of Geotechnical Engineering* 13:1-43.
- Behrman, M., 1914, A History of Three Great Public Utilities: Sewerage, Water and Drainage and their influence upon the Health and Progress of a Big City, in: *Convention of League of American Municipalities*, Milwaukee, WI.
- Berkes, F., 2012, Sacred ecology, New York: Routledge.
- Berrigan, M., Candies, T., Cirino, J., Dugas, R., Dyer, C., Gray, J., Herrington, T., Keithly, W., Leard, R., Nelson, J., 1991, The oyster fishery of the Gulf of Mexico, United States: a regional management plan.
- Blum, M. D., Roberts, H. H., 2009, Drowning of the Mississippi Delta due to insufficient sediment supply and global sea-level rise, *Nature Geoscience* 2(7):488-491.

- Bowker, G. and Star, S.L., 1999. Sorting things out. *Classification and its consequences*. Cambridge, MA: MIT Press.
- Breaux, A., Schneider, A., Kolker, A., Telfeyan, K., Kim, J., Johannesson, K., Cable, J., Coleman, D., 2013, Buried Distributaries as a Conduit for Groundwater Flow in Barataria Bay, Louisiana, *AGU Fall Meeting Abstracts* 1:1300.
- Brenner, Neil, and Christian Schmid. 2011. "Planetary Urbanization." In *Urban Constellations*, edited by Matthew Gandy, 10–13. Berlin: Jovis.
- Breunlin, R., Regis, H. A., 2006, Putting the ninth ward on the map: Race, place, and transformation in desire, New Orleans, *American Anthropologist* 108(4):744-764.
- Britton, D. F., 1996, Avenal v. United States: Does the State of Louisiana Have a Property Interest in the Salinity of Its Waters, *Ocean & Coastal LJ* 2:153.
- Callon, M., 1998, An essay on framing and overflowing: Economic externalities revisited by sociology. In Callon, M., *The Laws of Markets*, Oxford: Blackwell, 244–69.
- Campanella, R., 2002, Time and place in New Orleans: Past geographies in the present day, Pelican Publishing.
- Campanella, R., 2006. *Geographies of New Orleans: Urban fabrics before the storm* (pp. 193-203). Lafayette: Center for Louisiana Studies.
- Carse, A., 2012, Nature as infrastructure: Making and managing the Panama Canal watershed, *Social Studies of Science*:0306312712440166.
- Carse, A., 2014, Beyond the Big Ditch: Politics, Ecology, and Infrastructure at the Panama Canal, MIT Press.
- Carse, A. and Lewis, J.A., 2017, Toward a political ecology of infrastructure standards: Or, how to think about ships, waterways, sediment, and communities together. *Environment and Planning A*, 49(1), pp.9-28.
- Colten, C.E., 2006. *An unnatural metropolis: Wrestling New Orleans from nature*. Baton Rouge: LSU Press.
- Cowen, D., 2014. The deadly life of logistics: Mapping violence in global trade. University of Minnesota Press.
- CPRA, 2007. Louisiana's Comprehensive Master Plan for a Sustainable Coast - Integrated Ecosystem Restoration and Hurricane Protection. Louisiana Coastal Protection and Restoration Authority.
- CPRA, 2012. Louisiana's Comprehensive Master Plan for a Sustainable Coast - Integrated Ecosystem Restoration and Hurricane Protection. Louisiana Coastal Protection and Restoration Authority.
- CPRA, 2017. Louisiana's Comprehensive Master Plan for a Sustainable Coast - Integrated Ecosystem Restoration and Hurricane Protection. Louisiana Coastal Protection and Restoration Authority.
- Crona, B., Ernstson, H., Prell, C., Reed, M., Hubacek, K., 2011, Combining social network approaches with social theories to improve understanding of natural resource governance.
- Crutzen, P.J., 2006. The "anthropocene". In *Earth system science in the anthropocene* (pp. 13-18). Springer Berlin Heidelberg.
- Dabney, T. E., 1921, The Industrial Canal and Inner Harbor of New Orleans: History, Description and Economic Aspects of Giant Facility Created to Encourage Industrial Expansion and Develop Commerce, Board of Commissioners of the Port of New Orleans.
- Dokka, R.K., 2011. The role of deep processes in late 20th century subsidence of New Orleans and coastal areas of southern Louisiana and Mississippi. *Journal of Geophysical Research: Solid Earth*, 116(B6).

- Dalbom, C., Hemmerling, S., Lewis, J., 2014, Community Resettlement Prospects in Southeast Louisiana, Tulane Institute on Water Resources Law & Policy, New Orleans, LA.
- Day, J., et al., 2014, Perspectives on the Restoration of the Mississippi Delta, Springer.
- DeLanda, M., 2000. *1000 Years of Non-Linear History*. New York: Swerve Editions.
- Edwards, P.N., 2010. *A vast machine: Computer models, climate data, and the politics of global warming*. Cambridge, MA: MIT Press.
- El-Sayed, S.Z., 1961. Hydrological and Biological Studies of the Mississippi River-Gulf Outlet Project. A&M Project 236, Reference 61-20F. College Station, Texas: Texas A&M Research Foundation.
- Erixon Aalto, H., & Ernstson, H., 2017, Of plants, high lines and horses: Civics and designers in the relational articulation of values of urban natures. *Landscape and Urban Planning*, 157, 309–321.
- Ernstson, H., 2013, The social production of ecosystem services: A framework for studying environmental justice and ecological complexity in urbanized landscapes, *Landscape and Urban Planning* 109(1):7-17.
- Ernstson, H., Barthel, S., Andersson, E., Borgström, S. T., 2010, Scale-crossing brokers and network governance of urban ecosystem services: The case of Stockholm, *Ecology and Society* 15(4):28-28.
- Ernstson, H., Sörlin, S., 2009, Weaving protective stories: Connective practices to articulate holistic values in Stockholm National Urban Park, *Environment and Planning A* 41(6):1460-1479.
- Ernstson, H., Sörlin, S., 2013, Ecosystem services as technology of globalization: On articulating values in urban nature, *Ecological Economics* 86:274-284.
- Evans, J. P., 2011, Resilience, ecology and adaptation in the experimental city, *Transactions of the Institute of British Geographers* 36(2):223-237.
- Farmer, P., 2004. *Pathologies of power: Health, human rights, and the new war on the poor* (Vol. 4). University of California Press.
- Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, 30(1), 441–473.
- Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*, 16(3), 253–267.
- Freudenburg, W. R., Gramling, R., Laska, S., Erikson, K. T., 2009a, Disproportionality and Disaster: Hurricane Katrina and the Mississippi River-Gulf Outlet, *Social Science Quarterly* 90(3):497-515.
- Freudenburg, W. R., Gramling, R. B., Laska, S., Erikson, K., 2009b, Catastrophe in the making: the engineering of Katrina and the disasters of tomorrow, Island Press.
- Germany, K.B., 2007. *New Orleans after the promises: poverty, citizenship, and the search for the Great Society*. University of Georgia Press.
- Giosan, L., 2014. Protect the world's deltas. *Nature*, 516(7529), p.31.
- Graham, S., Marvin, S., 2001, Splintering urbanism: networked infrastructures, technological mobilities and the urban condition, Psychology Press.
- Graham, S., McFarlane, C., 2014, Infrastructural Lives: Urban Infrastructure in Context, Routledge.
- Gramling, R., Freudenburg, W. R., Laska, S., Erikson, K. T., 2011, Obsolete and Irreversible: Technology, Local Economic Development, and the Environment, *Society and Natural Resources* 24(6):521-534.
- Hallegatte, S., Green, C., Nicholls, R.J. and Corfee-Morlot, J., 2013. Future flood losses in major coastal cities. *Nature climate change*, 3(9), pp.802-806.

- Hodson, M. and Marvin, S., 2010. *World cities and climate change: Producing urban ecological security*. McGraw-Hill Education (UK).
- Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecological Systems*, 4, 1–23
- Holling, C. S., Meffe, G. K., 1996, Command and control and the pathology of Natural Resource Management, *Conservation Biology* 10(2):328–337.
- Hornbeck, R., Naidu, S., 2014, When the Levee Breaks: Black Migration and Economic Development in the American South, *American Economic Review* 104(3):963–90.
- Hornborg, A., 2009. Zero-sum world: challenges in conceptualizing environmental load displacement and ecologically unequal exchange in the world-system. *International Journal of Comparative Sociology*, 50(3–4), pp.237–262.
- Howes, N. C., FitzGerald, D. M., Hughes, Z. J., Georgiou, I. Y., Kulp, M. A., Miner, M. D., Smith, J. M., Barras, J. A., 2010, Hurricane-induced failure of low salinity wetlands, *Proceedings of the National Academy of Sciences* 107(32):14014–14019.
- Jacobs, D., 2015, Louisiana's physical footprint could be determined over next 10 years, coastal protection chair says, in: *Greater Baton Rouge Business Report*, Baton Rouge, LA.
- Jeansonne, G., 2006. *Leander Perez: Boss of the delta*. University of Mississippi Press.
- Kaika, M. (2017). "Don't call me resilient again!": The New Urban Agenda as immunology... or... what happens when communities refuse to be vaccinated with "smart cities" and indicators. *Environment and Urbanization*, 29(1), 89–102.
- Katz, A. (1984) "Port butts land for terminal," *New Orleans Times-Picayune/States-Item*. April 4, 1984, Section 1, Page 22.
- Kelman, A., 2003. *A river and its city: The nature of landscape in New Orleans*. University of California Press.
- Kolker, A. S., Cable, J. E., Johannesson, K. H., Allison, M. A., Inniss, L. V., 2013, Pathways and processes associated with the transport of groundwater in deltaic systems, *Journal of Hydrology* 498:319–334.
- Lade, S.J., Niiranen, S., Hentati-Sundberg, J., Blenckner, T., Boonstra, W.J., Orach, K., Quaas, M.F., Österblom, H. and Schlüter, M., 2015. An empirical model of the Baltic Sea reveals the importance of social dynamics for ecological regime shifts. *Proceedings of the National Academy of Sciences*, 112(35), pp.11120–11125.
- Landphair, J., 1999, Sewerage, sidewalks, and schools: the New Orleans Ninth Ward and public school desegregation, *Louisiana History*:35–62.
- Landphair, J., 2007, "The Forgotten People of New Orleans": Community, Vulnerability, and the Lower Ninth Ward, *The Journal of American History* 94(3):837–837.
- Lewis, J., 2015. *Deltaic dilemmas: Ecologies of infrastructure in New Orleans* (Doctoral dissertation, Stockholm Resilience Centre, Stockholm University).
- Lewontin, R. C., 1969, The meaning of stability. *Brookhaven Symposia in Biology*, 22, 13–24.
- Lewontin, R., & Levins, R., 1985, *The Dialectical Biologist*. Harvard: Harvard University Press.
- Lipset, S. M., & Rokkan, S., 1967, Cleavage structures, party systems, and voter alignments: an introduction.
- Massey, D. 2005, *For Space*. London: Sage
- Massey, D., 2004. Geographies of Responsibility. *Geografiska Annaler, Series B: Human Geography*, 86(1): 5–18
- Mazmanian, D. A., Nienaber, J., 1979, Can organizations change?: Environmental protection, citizen participation, and the Corps of Engineers, Brookings institution Washington, DC.

- McGranahan, G., Balk, D., Anderson, B., 2007, The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones, *Environment and Urbanization* 19(1):17-37.
- Melosi, M. V., 2000, *The Sanitary City: urban infrastructures from colonial times to the present*, Johns Hopkins University Press, Baltimore, MD. .
- Möllmann, C., Folke, C., Edwards, M., Conversi, A., 2015, Marine regime shifts around the globe: theory, drivers and impacts, *Philosophical Transactions of the Royal Society B: Biological Sciences* 370(1659).
- Monstadt, J., 2009, Conceptualizing the political ecology of urban infrastructures: insights from technology and urban studies, *Environment and Planning A* 41(8):1924-1942.
- Murdoch, J., 2006, *Post-structuralist Geography: A guide to relational space*, Sage, London.
- Muth, D.P., 2014. The once and future delta. In *Perspectives on the Restoration of the Mississippi Delta* (pp. 9-27). Springer Netherlands.
- Nadasdy, P., 2007, Adaptive co-management and the gospel of resilience. In D. Armitage, F. Berkes, & N. Doubleday (Eds.), *Adaptive Co-Management: Collaboration, Learning and Multi-Level Governance* (pp. 208–227). Vancouver, Toronto: UBC Press.
- Nelson, D.R., Adger, W.N. and Brown, K., 2007. Adaptation to environmental change: contributions of a resilience framework. *Annual review of Environment and Resources*, 32.
- Paavola, J., Adger, W. N., 2006, Fair adaptation to climate change, *Ecological Economics* 56(4):594-609.
- Pachauri, R.K., Allen, M.R., Barros, V.R., Broome, J., Cramer, W., Christ, R., Church, J.A., Clarke, L., Dahe, Q., Dasgupta, P. and Dubash, N.K., 2014. *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change* (p. 151). IPCC.
- Pendall, R., Foster, K. A., Cowell, M., 2009, Resilience and regions: building understanding of the metaphor, *Cambridge Journal of Regions, Economy and Society*:rsp028.
- Poirrier, M. A., 2013, Effects of closure of the Mississippi River Gulf Outlet on saltwater intrusion and bottom water hypoxia in Lake Pontchartrain, *Gulf and Caribbean Research* 25:105-109.
- Ramos, S. J., 2014, Planning for competitive port expansion on the US Eastern Seaboard: the case of the Savannah Harbor Expansion Project, *Journal of Transport Geography* 36:32-41.
- Rancière, J., 2010, *Dissensus: On politics and aesthetics*. London & New York: Bloomsbury.
- Reed, M. S., Evely, A. C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C., 2010, What is Social Learning?, *Ecology & Society* 15(4).
- Rocha, J., Yletyinen, J., Biggs, R., Blenckner, T., Peterson, G., 2015, Marine regime shifts: drivers and impacts on ecosystems services, *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 370(1659):20130273.
- Rodgers, D., O'Neill, B., 2012, Infrastructural violence: Introduction to the special issue, *Ethnography* 13(4):401-412.
- Saltus, C. L., Suir, G. M., Barras, J. A., 2012, Land and Forest Area Changes in the Vicinity of the Mississippi River Gulf Outlet , Central Wetlands Region , 1935-2010 Land and Forest Area Changes in the Vicinity of the Mississippi River Gulf Outlet , Central Wetlands Region , 1935-2010, (March).

- SBC, 2006, A failure of initiative: Final report of the select bipartisan committee to investigate the preparation for and response to Hurricane Katrina, US Government Printing Office.
- Scheffer, M., Bascompte, J., Brock, W.A., Brovkin, V., Carpenter, S.R., Dakos, V., Held, H., Van Nes, E.H., Rietkerk, M. and Sugihara, G., 2009. Early-warning signals for critical transitions. *Nature*, 461(7260), p.53.
- Scheffer, M. and Carpenter, S.R., 2003. Catastrophic regime shifts in ecosystems: linking theory to observation. *Trends in ecology & evolution*, 18(12), pp.648-656.
- Seto, K.C., 2011. Exploring the dynamics of migration to mega-delta cities in Asia and Africa: Contemporary drivers and future scenarios. *Global Environmental Change*, 21, pp.S94-S107.
- Seed, R. B., Bea, R., Athanasopoulos-Zekkos, A., Boutwell, G., Bray, J. D., Cheung, C., Cobos-Roa, D., Ehrensing, L., Harder Jr, L., Pestana, J., 2008, New Orleans and hurricane Katrina. II: The central region and the lower ninth ward, *Journal of geotechnical and geoenvironmental engineering*.
- Seed, R. B., Bea, R. G., Abdelmalak, R. I., Athanasopoulos, A. G., Boutwell Jr, G. P., Bray, J. D., Briaud, J.-L., Cheung, C., Cobos-Roa, D., Cohen-Waeber, J., 2006, Investigation of the Performance of the New Orleans Flood Protection System in Hurricane Katrina on August 29, 2005.
- Shaffer, G. P., Day Jr, J. W., Mack, S., Kemp, G. P., van Heerden, I., Poirrier, M. A., Westphal, K. A., FitzGerald, D., Milanes, A., Morris, C. A., 2009, The MRGO Navigation Project: a massive human-induced environmental, economic, and storm disaster, *Journal of Coastal Research*:206-224.
- Shallat, T., 2014. *Hope for the Dammed: The US Army Corps of Engineers and the Greening of the Mississippi*. American Public Works Association.
- Shallat, T., 2000. In the wake of Hurricane Betsy. *Transforming New Orleans and Its Environs*, pp.120-138.
- Slawsky, R. 2004. "Sides remain far apart in MRGO debate," *New Orleans Citybusiness*, August 23, 2004, pp 5-6.
- SLC, 2015. "The citizens of Louisiana deserve the truth," Save Louisiana Coalition open letter, available from <http://www.thesavelouisianacoalition.com/Rebuttal.pdf>.
- Slingerland, R. and Smith, N.D., 2004. River avulsions and their deposits. *Annu. Rev. Earth Planet. Sci.*, 32, pp.257-285.
- Spalding, M. D., Mclvor, A. L., Beck, M. W., Koch, E. W., Möller, I., Reed, D. J., Rubinoff, P., Spencer, T., Tolhurst, T. J., Wamsley, T. V., 2014, Coastal ecosystems: a critical element of risk reduction, *Conservation Letters* 7(3):293-301.
- Snell, J. 2015. "Two spots on a map highlight the bitter fight over how to fix Louisiana's coast" Fox8 New Orleans, available from <http://www.fox8live.com/story/23078045/two-spots-on-a-map-highlight-bitter-fight-over-how-to-fix-louisianas-coast>.
- Snowden, J.O., Simmons, W.B., Traughber, E.B. and Stephens, R.W., 1977. Differential subsidence of marshland peat as a geologic hazard in the greater New Orleans area, Louisiana. *Transactions of the Gulf Coast Association of Geological Societies XXVII*, pp. 169-179.
- Star, S.L. and Ruhleder, K., 1996. Steps toward an ecology of infrastructure: Design and access for large information spaces. *Information systems research*, 7(1), pp.111-134.
- Steffen, W., Grinevald, J., Crutzen, P. and McNeill, J., 2011. The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, 369(1938), pp.842-867.

- Stengers, I., 2005, The cosmopolitical proposal, *Making things public: Atmospheres of democracy*:994-1003.
- Sumaila, U. R., Cisneros-Montemayor, A. M., Dyck, A., Huang, L., Cheung, W., Jacquet, J., Kleisner, K., Lam, V., McCrea-Strub, A., Swartz, W., 2012, Impact of the Deepwater Horizon well blowout on the economics of US Gulf fisheries, *Canadian Journal of Fisheries and Aquatic Sciences* 69(3):499-510.
- Teal, J., Best, R., Caffrey, J., Hopkinson, C., McKee, K., Morris, J., Newman, S., Orem, B., 2012, Mississippi River freshwater diversions in Southern Louisiana: effects on wetland vegetation, soils, and elevation, *Final report to the State of Louisiana and the US Army Corps of Engineers through the Louisiana Coastal Area Science & Technology Program*.
- Tessler, Z.D., Vörösmarty, C.J., Grossberg, M., Gladkova, I., Aizenman, H., Syvitski, J.P.M. and Foufoula-Georgiou, E., 2015. Profiling risk and sustainability in coastal deltas of the world. *Science*, 349(6248), pp.638-643.
- Thomas, D. S., Twyman, C., 2005, Equity and justice in climate change adaptation amongst natural-resource-dependent societies, *Global Environmental Change* 15(2):115-124.
- Tiner, R.W., 2013. *Tidal wetlands primer: an introduction to their ecology, natural history, status, and conservation*. University of Massachusetts Press.
- Tompkins, E. L., Adger, N. W., 2004, Does Adaptive Management of Natural Resources Enhance Resilience to Climate Change, *Ecology and Society* 9(2):10-10.
- Upton, H. F., 2011, The Deepwater Horizon oil spill and the Gulf of Mexico fishing industry, Congressional Research Service, Library of Congress.
- USACE, 2009. Supplemental Environmental Impact Statement Inner Harbor Navigation Canal Lock Replacement Project, Orleans Parish, Louisiana. US Army Corps of Engineers. Available from http://www.mvn.usace.army.mil/Portals/56/docs/PD/Projects/IHNClockRepl/2009/2009%20Final_SEIS_03_23_09.pdf.
- USACE, 2011. Meeting minutes for the US Army Corps of Engineers New Orleans District, Mississippi River Gulf Outlet Restoration Plan, Public Meeting transcript, Chalmette Louisiana, 20 January 2011.
- Walker, B. and Meyers, J., 2004. Thresholds in ecological and social-ecological systems: a developing database. *Ecology and society*, 9(2).
- Wamsley, T. V., Cialone, M. A., Smith, J. M., Atkinson, J. H., Rosati, J. D., 2010, The potential of wetlands in reducing storm surge, *Ocean Engineering* 37(1):59-68.
- Watson, V., 2003, Conflicting rationalities: Implications for planning theory and ethics. *Planning Theory & Practice*, 4(4), 395-407.
- Wells, A. E., 2004, Good neighbors? Distance, resistance, and desegregation in metropolitan New Orleans, *Urban Education* 39(4):408-427.
- Whatmore, S. J. (2009). Mapping knowledge controversies: Science, democracy and the redistribution of expertise. *Progress in Human Geography*, 33(5), 1-12.
- Whatmore, S. J., Lane, S. N., Odoni, N. A., Ward, N., Bradley, S., 2011, Coproducing flood risk knowledge: redistributing expertise in critical participatory modelling, *Environment and Planning A* 43(7):1617-1633.
- Whatmore, S. J., & Landström, C., 2011, Flood apprentices: an exercise in making things public. *Economy and Society*, 40(4): 582-610.
- Keithly, W.R. and Kazmierczak, R.F., 2006. Economic analysis of oyster lease dynamics in Louisiana. *Final Report. Louisiana Department of Natural Resources, Baton Rouge, LA, USA*, 34.
- Wieder, A., 1987, The New Orleans School Crisis of 1960: Causes and Consequences, *Phylon* (1960):122-131.

- Wolf, J., Adger, W. N., Lorenzoni, I., Abrahamson, V., Raine, R., 2010, Social capital, individual responses to heat waves and climate change adaptation: An empirical study of two UK cities, *Global Environmental Change* 20(1):44-52.
- Zarycki, T., 2007, An interdisciplinary model of centre-periphery relations: A theoretical proposition, *Regional and Local Studies*, Special Issue:110-130.