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Toward Seaport Resilience for Climate Change Adaptation: Stakeholder Perceptions of Hurricane Impacts in Gulfport (MS) and Providence (RI)

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TOWARD SEAPORT RESILIENCE FOR CLIMATE CHANGE ADAPTATION: STAKEHOLDER PERCEPTIONS OF HURRICANE IMPACTS IN GULFPORT (MS) AND PROVIDENCE (RI)

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Highlights

- We created a plausible hurricane scenario for the Ports of Gulfport (MS) and Providence (RI)
- We identified and interviewed the "stakeholder cluster" around each port
- We identified stakeholder perceptions of the broad range of impacts that a hurricane hitting the port would have upon the stakeholder cluster.
- We propose a typology for storm impacts on the port cluster that includes direct damages, indirect costs, and intangible consequences resulting from such a storm hitting the port.
- We found that the intangible consequences were of great concern to stakeholders.
- We assessed how the costs of the impacts would be borne by different types of stakeholders and found that intangible consequences in particular would be borne by society at large.
- We found that formal planning and policy did not address many of these stakeholder concerns and in particular did not address intangible consequences.

Keywords

Climate change adaptation, seaports, stakeholder cluster, storm resilience, impact assessment, case studies

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1. Introduction

A growing body of research indicates that climate change is having and will continue to have a range of impacts on human-environmental systems (IPCC 2012; NRC 2010). Attention must be given to reducing vulnerability and increasing the resilience of these systems (Patt 2013; Moser and Boykoff 2013). Because the climate-related changes include increased storm activity (Emanuel 2013) and a rise in sea levels (Rahmstorf 2010), seaports are expected to be especially vulnerable (Becker et al. 2013; McEvoy et al. 2013; Asariotis and Benamara 2012), as many ports are -by necessity- located in environmentally sensitive and high-risk locations. Seaports and maritime shipping play vital roles in global trade and regional socio-economic stability (AAPA 2013; World Bank 2010). With 99% of overseas U.S. trade by weight, carried by ship (AAPA 2013), ports are the backbone of the national economy and International trade. Ports serve as delivery centers of public goods and critical resources for the region of their geographical location, to a wide variety of stakeholders such as public agencies, community groups, and private businesses (Hall and Jacobs 2007; Notteboom and Winkelmans 2002) Recent projections suggest a potentially crippling increase in asset exposure in each of the world's 136 port mega-cities during this century (Nicholls et al. 2008; Lenton et al. 2009; Coumou and Rahmstorf 2012). Combined, these new conditions of elevated sea levels plus more frequent and intense tropical storms could result in a 10 to 100-fold increase in the likelihood of a major storm event (Tebaldi et al. 2012; Grinsted et al. 2013).

There is wide consensus that stakeholder engagement and participation will be an essential component of adaptation (Wilbanks and Kates 1999; Eakin and Luers 2006) and that the assessment of impacts should be conducted on a scale that is aligned with the scale at which management occurs (Cash and Moser 2000). Thus, the current research is an academic exploration focusing on the causes and consequences of harm and loss for particular peoples and places, in this case stakeholders of seaports. It builds on the theory that stakeholder perceptions must be considered for effective assessment and management of such consequences (Eakin and Luers 2006).

Understanding the potential impacts of storms for different port stakeholders can help them plan for a level of storm preparedness that is more appropriate for the new environmental conditions presented by climate change (Koetse and Rietveld 2009). Without such understanding, stakeholders are left to plan in a way that does not necessarily account for many indirect costs or intangible consequences of such storm events -- impacts that will ultimately be borne by society. To plan for a future with more extreme events in coastal areas, decision makers need to understand *what kinds of impacts* result from storms hitting the local port, *which stakeholders* are affected, and how *to incorporate stakeholder concerns* into the planning process. In this article, we thus address the following three questions through case studies of two highly-exposed seaports:

1) **How do port stakeholders in Gulfport (MS) and Providence (RI) perceive the impacts of a major hurricane hitting the port, and**
2) **How will internal and external stakeholders bear the costs resulting from a hurricane hitting the port?**
3) **In what ways are port stakeholders considering the resilience of the port in planning and policy?**

Our study provides a fine-grained analysis of hurricane impacts on seaport stakeholders through a review of planning and policy documents, an analysis of interviews, and a review of each port's resilience plans. We invited key stakeholders in the port cluster to review and respond to a hurricane scenario. We identified and catalogued the wide range of impacts of storm events on the port described by interviewees, as well analyzed which stakeholders would bear the cost of impacts. We also examined how stakeholder concerns were accounted for in planning and policy.

The target audience for this study is the constellation of planners, practitioners, and decision-makers in the public and private sectors with responsibility for the formulation and implementation of resilience plans and policy for seaports. They include: port planners, coastal managers, urban planners, federal agencies, and others. The audience also includes the members of the academic community who are concerned about the issues of stakeholder engagement and furthering the efficacy of resilience planning.

Following the Introduction, Section 2 of this paper provides the background and context for the study through a discussion of climate adaptation, the climate change challenge for seaports, the seaport stakeholder cluster, and seaport resilience planning. We also discuss some of the currently applied traditional methods of impact assessment, many of which are either at the wrong scale or not suitable for *ex ante* assessments that decision makers need in order to plan for more resilient seaports. In Section 3, we outline our approach and methods for the case studies and provide an overview of the ports of Gulfport and Providence. Section 4 reports the results of the study as a typology for hurricane impacts, illustrated with examples from key stakeholders and the documents reviewed, with an assessment of which stakeholders will likely bear the costs of specific impacts. Finally, Section 5 discusses the results in aggregate, addresses each of the

three original research questions. Though we did not intend this research as a comparative case study, Section 5 also addresses some of the similarities and differences between these two cases. We conclude with some implications for policy and a short discussion of the next steps for this line of research.

2. Background

2.1. The climate challenge for seaports

Climate change is accepted by the scientific community as an unequivocal fact (IPCC 2007). Impacts of climate change are already being felt by society, and it is likely that impacts will in the future affect all sectors of society and have wide-reaching impacts on human health, energy, marine environments and fisheries, transportation infrastructure, forests, conservation areas, food supplies and global security (IPCC 2007; IPCC 2012; NRC 2010). Recent global projections suggest that sea levels could rise by as much as 1.9 meters by 2100 (Schaeffer et al. 2012; Vermeer and Rahmstorf 2009), which would exacerbate storm-surge impacts and wave damage in many regions (Lin et al. 2012; IPCC 2012) especially if the intensity and frequency of tropical storms also increase (Emanuel 2013; Bender et al. 2010). These new conditions pose substantial challenges to ports (Asariotis and Benamara 2012; Oh and Reuveny 2010) due to the exposed locations of ports in coastal zones, low-lying areas, the life spans of infrastructure assets, and their interdependence with trade, shipping and inland transport services that are also climatically vulnerable. The coastal or estuarine location of seaports suggests that the mean sea level (MSL) rise, higher storm surges and river floods (Tebaldi et al. 2012; Von Storch et al. 2008; Jonkeren et al. 2013), increased hurricane intensities/destructiveness (Elsner et al. 2008; Emanuel 2005) and potential changes in wave regimes (IPCC 2012) could cause significant damage and

operational delays (Haveman and Shatz 2006; EQECAT Inc. 2012; PANYNJ 2012). These extreme events cause coastal inundation/erosion, wind hazards and inland floods that can disrupt entire transportation networks (USCCRP 2008). Some regions will find that the local sea level rise will exceed the global mean, causing additional impacts from business losses due to these natural disasters (Esteban et al. 2009; Hallegatte et al. 2011).

Many ports have already suffered from catastrophic storms even before climate change. Between 1960-2010, 282 U.S. ports had a named tropical storm pass within 50 kilometers (Figure 1). In particular, ports along the U.S. Gulf and East Coasts have been hit directly by hurricanes, with damages totaling in the billions of dollars (Blake et al. 2011). Hurricane Katrina caused $100 million to Mississippi's ports (PEER 2006) and Hurricane Sandy generated over $50 billion in damage to the New York and New Jersey region (EQECAT Inc. 2012) and the Port of New York was shut down for over eight days (PANYNJ 2012).

Figure 1 -- Map of U.S. ports within 50km of named storm

2.2. Climate change adaptation - Overview of theory and terms

Adapting to the impacts of climate change has become a focus for researchers and the decision makers at local, state, national, and International levels (NRC 2010; IPCC 2012), though little work has addressed ports specifically. Adaptation, as defined by the Intergovernmental Panel on Climate Change (IPCC), means "any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007).

The adaptation process incorporates steps that may be iterative, though defining the problem and

initial solutions through identifying risks, vulnerabilities, and strategies, is generally a first step. This requires an assessment of which stakeholders are at risk and should thus be engaged in the adaptation planning process, what the specifics risks and impacts may be, and in what ways systems may be vulnerable. Assessing vulnerability has been the subject of a great deal of research in the emerging area of climate adaptation (Bierbaum et al. 2013; Preston et al. 2010), though approaches remain fragmented (Janssen et al. 2006).

As represented in (Figure 2), the first steps in the adaptation process in general, and for ports specifically, requires the engagement of stakeholders and thus an assessment who should thus be engaged in the adaptation planning process, what the specifics risks are, and in what ways the port system in vulnerable.

Before identifying each stakeholder's position, implication and responsibility in this complex structure, here is an overview of terminology used in the present research, to establish context:

Risk is the product of the probability of an event and the damage consequences that result. For ports, the risk manifests primarily as a function of exposure to storms and the impacts that result from a storm hitting the port.

Impacts are the effects on natural and human systems of disasters and are a key component of vulnerability.

Vulnerability is defined as, “the propensity or predisposition to be adversely affected … including the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover form the adverse affects of physical events” (IPCC 2012).

Capacity is defined as "the combination of all the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to achieve established goals" (IPCC 2012).

Exposure, in turn, is defined as "the presence of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by physical events and which, thereby, are subject to potential future harm, loss, or damage" (IPCC 2012).

Resilience generally refers to the "ability of a system to absorb disturbance and still retain its basic function and structure" (Walker et al. 2006). A large body of research has focused on the resilience of natural coastal systems (Adger et al. 2005), due to concerns about the combined pressures of human population growth and threats from natural disasters. Resilience is also topic of growing interest among researchers in other areas ranging from architectural systems to institutional (Eakin and Luers 2006), ecological systems (Walker et al. 2006) and security studies (Coaffee and Wood 2006). Resilience theory and natural hazards research provides a lens focusing on the problem identification and the implementation of solutions that include disaster response and planning (Godschalk 1999; Birkmann et al. 2008; Collier et al. 2010). The National Infrastructure Advisory Council defines *infrastructure resilience* as the ability to reduce the magnitude and/or duration of disruptive events (NIAC 2009). The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event (O'Rourke 2007).

A first step in approaching the climate change adaptation for seaports is establishing a framework that provides a visual overview of a complex process. These help guide the

adaptation process, allowing researchers and practitioners to better understand the necessary steps for building resilience of the systems with which they are particularly concerned (NRC, 2010; Moser and Ekstrom 2010; Turner et al. 2003; Allison et al. 2009; Birkmann et al. 2013). We use the framework represented in Figure 2 to provide context for this research because it represents a common and rational approach to planning (Moser and Ekstrom 2010). This framework emphasizes the importance of stakeholder engagement in adaption planning. Researchers and practitioners increasingly recognize stakeholder engagement as an essential component of successful adaptation planning processes and resilience building (Moser and Boykoff 2013; Eakin and Luers 2006). Empirical evidence has shown that without support from stakeholders, coastal management decisions are unlikely to be successfully implemented (Tompkins et al. 2008). Stakeholder input helps assess and identify future socioeconomic impacts (Van Kleef et al. 2006) that can result from hurricanes striking at seaports. Assessment of these types of impacts, as well as the options for adaptation, are the first steps in the adaptation process. Though other research has relied on stakeholder input to assess flood risk (Van Kleef et al. 2006), impacts of sea level rise (Poumadère et al. 2008), and the broader regional impacts of climate change more generally (Shackley and Deanwood 2002), these types of impacts assessments have not been applied for stakeholders of seaports.

Figure 2 -- Climate adaptation process (NCADAC *Draft*)

2.3. What is seaport resilience?

When used in reference to a seaport, "resilience" has many different meanings to different types of stakeholders. In a case study of the Port of New York and New Jersey, for example, Smythe (2013) found large variations in how stakeholders conceptualized the resilience of the port. Some

described it in social terms, emphasizing the interconnectedness of different sectors. Others thought primarily about the physical infrastructure and the transportation systems' ability to bounce back and recover, and others described it in economic terms, emphasizing the resilience of supply chains, and others. In general though, a resilient port can "withstand an extreme natural event without suffering devastating losses, damage, diminished productivity or quality of life, without a large amount of assistance from outside the community" (Mileti 1999). For the purposes of this study and its focus on storm resilience, we define a *resilient port* more specifically as one that, in the face of storm events, may continue to serve its region for the following goals: facilitating trade as a conduit for the exchange of resources, materials, and finished products; facilitating business success and profit to firms; an engine for local, state, and/or national economic growth and stability; and a public good that minimizes environmental harm and contributes to residents' quality of life. Actors may share these goals, but prioritize them differently, as different types of stakeholders have widely varying interests in the port.

Since a port serves a diverse community of stakeholders and society at large, port resilience may also be considered as a *public good* from which all stakeholders may benefit. This concept underlies the value of considering all stakeholders' perspectives when assessing impacts of storm events and strategies to build resilience. A *public good* is both non-excludable and non-rivalrous, since individuals cannot be effectively excluded from its benefit, and the benefit by one individual does not reduce the benefit to others (Besanko and Braeutigam 2010). Egli (2012) shows how- on a national scale- the U.S. benefits from strengthening the Nation's awareness and inter-agency coordination around the public good aspects of infrastructure resilience. Although little research has been conducted on this particular aspect of seaport storm resilience, in which the seaport is considered a *public good*, some insights can be obtained from similar work that

focused on port security, that underscore the value that planning for the long-term functioning of seaports can have for all stakeholders. Since the terrorist attacks of 9/11, much attention has been paid to the role of seaports play in such attacks. Haveman and Shatz (2006) suggest that the loss of port functionality due to these external strikes can result in a cascade of impacts on supply chains, port-dependent businesses and consumers who rely on the goods and materials handled by the port. For the same reason national defense has been identified as a *public good* that prevents these cascading impacts, seaport storm resilience may be considered a worthy goal, since similar outcomes can occur from the impact of a major storm hitting a port. Some of these impacts are quantifiable in economic terms, while others have intangible consequences on quality of life or the environment. Since stakeholders of a port may be expected to bear some of the costs associated with a hurricane strike, understanding the impacts and resilience strategies available, can lead to benefits for the port and the port stakeholders.

2.4. Stakeholders of the port

Scholars and policy makers have stressed the importance of identifying stakeholders (Bryson 2004) and including a broad range of stakeholders' perspectives in developing adaptive responses to climate change (Few et al. 2007) and for transport planning in particular (Ward 2001). The primary function of a port is the transfer of cargo and/or passengers between a waterway and the shore (Talley 2009), but today's ports are more than simply a system of channels, wharves, and multi-modal connections. Thus, the stakeholders who depend upon the port functionality are diverse. Ports serve as profit centers for a variety of businesses, including shippers, shipping agents, energy companies, importers and exporters, and port authorities. They facilitate the transport of energy resources, building materials, finished products, and chemicals. Ports also share ecologically sensitive territory with other stakeholders, such as commercial and

recreational users. Ports may also be considered a cultural element, embedded within and held accountable for the goals of a larger society (Burroughs 2005).

Stakeholders of a port may be defined as any group or individual who can affect or is affected by the achievement of the organization's objectives (Freeman 2010). As described by Notteboom and Winkelman (2002), the principal stakeholders of the port include the port operator (often a public port authority) and the firms that are directly engaged in the transfer of cargo or passengers. However, many stakeholders of the port share a wide variety of goals and missions with respect to the long-term functioning of the port, including business success, facilitating trade, economic growth, and public goods and services. In a sense, stakeholders of a port may include almost anybody (Mitchell et al. 1997), numbering in the tens or hundreds of thousands or more, -- if one includes all neighbors, residents depending on goods shipped through the port, and the customers throughout a supply chain. However, climate adaptation and building resilience to storm events at ports will most likely be carried out by those individuals and groups who will be directly affected, and who may assume responsibility for implementing and sustaining the adaptation measures over time (NRC 2010), thus for the purposes of this study, we limit the stakeholders to the *port stakeholder cluster* discussed in the following section.

Though ports have been previously considered in academic research, most studies have confined analysis to the port authority itself or to the supply chain, of which the port is one component (Hall and Jacobs 2010; Goss 1990; Haezendonck 2001). However, as Hall and Jacobs (2007) noted, numerous other organizations must be considered within the port context. Port systems incorporate numerous independent firms and multi-modal transportation connections in order to provide services that would lead to economic growth and stability to their regions. Due to the complexity of port systems and the variety of ways that stakeholders depend upon port

functioning, a representative sampling of stakeholder concerns is necessary in order to develop a richer picture of the impacts beyond the concerns addressed by port operators.

Strategic management scholars use *cluster analysis* to understand the "actors that can affect or are affected by the achievement of a firm's objectives" (Freeman 2010). Although *clusters* have traditionally been defined as "spatially concentrated groups of firms competing in the same or related industries, that are linked through vertical and horizontal relationships" (Porter 1998), De Langen (2004) expanded this definition from "all economic activities related to the arrival of goods and ships," to include "populations consisting of business units, associations, and public or private organizations". Since de Langen employed the cluster concept as a lens through which the *economic* performance of the port may be viewed, the actors that make up the cluster consist primarily of firms. For the purposes of the present work, we expand the definition of cluster further to place a greater emphasis on stakeholders who have interests beyond the profit motives that drive the port-related firms.

Thus, the *cluster* in this research loosely binds the group of organizations that have a stake in the long-term resilience of a port. Drawing absolute boundaries around this cluster is difficult or impossible, due to the global nature of the transportation network in which ports participate. Therefore, the port stakeholder cluster concept here includes the key stakeholders that have an interest in the resilience of a port and can play some role in planning or decision-making.

The *port stakeholder cluster* (De Langen 2004; Haezendonck 2001) may be divided into two primary categories: internal and external stakeholders (Figure 3). Those stakeholders that are part of the port authority organization (e.g., the port operator, shareholders, managers, and employees) may be considered as *internal stakeholders* and are generally most concerned with

the return on investment, shareholder/stakeholder value and/or the creation of wealth. A diverse array of actors and organizations fall into the broader category of *external stakeholders*.

Figure 3 -- Stakeholder cluster (Based on Notteboom and Winkelman, 2002)

These *external stakeholders* include *economic/contractual stakeholders* that are involved in certain port operations such as stevedoring companies, shipping agencies, insurers, ship repair services, port tenants, and the like. These stakeholders tend to have profit-oriented missions and many have the agency to shift locations should a major storm strike at the port. For example, a shipping company can divert its cargo to a different port in the event of a disaster at its original destination.

Public policy stakeholders include government agencies responsible for transport and economic affairs, as well as environmental agencies, planning departments, and emergency management agencies. These can be local (e.g., city planning and zoning commissions), state (e.g., coastal management programs and departments of transportation), and federal (e.g., the U.S. Coast Guard, the Federal Emergency Management Agency, the U.S. Army Corps of Engineers). These stakeholders have responsibility for facilitating commerce, protecting the environment, and other aspects of public welfare.

Community/environmental stakeholders consist of community groups, neighboring residents, the general (tax paying) public, environmental groups, and others. These types of groups typically advocate on behalf of a particular cause (e.g., water quality) or population (e.g., a residential neighborhood around a port). These community stakeholders may not always recognize their role until some event brings their dependence on the port to their attention. This may include a disaster at the port, plans for the development of port facilities, or a shift in the type of business

being conducted at the port.

Though not explicitly included in Notteboom and Winkelmans' typology, *academic research stakeholders* can also play a role in port planning development. These may include academic organizations or non-governmental groups that conduct independent work or are contracted by another stakeholder. Particularly with regard to resilience or economic development plans, researchers can provide information to the port's planning process. For example, weather forecasting, climate projections, and economic models may be used to inform the decision-making process. In Providence, the University of Rhode Island's (URI) Coastal Resources Center provides facilitation and communication expertise that aids in the development of statewide policy.

2.5. Impacts of storm events at ports and assessment techniques

Identifying the specific impacts serves as a first step toward adaptation, before strategies to reduce (or transfer) risk and mitigate disasters can be identified, assessed, and selected (Moser and Ekstrom 2010; NCADAC Draft; IPCC 2007). Many databases account for disaster losses and numerous analyses have employed these databases to generate comparisons of risk on a national or International scale (Allison et al. 2009; GCRP 2009; Hanson et al. 2010). One study, the UNDP's "Disaster Risk Index," uses mortality data to create a quantitative measure that allows for a comparison of risk levels of various hazards between countries (Peduzzi et al. 2009). Another, called the "Hotspots Project," developed a world map of hotspots that illustrates where the risk of mortality and economic losses due to natural hazards is greatest (Birkmann 2007). Depending on the database, losses are generally reported as direct monetary (observable damage to infrastructure) and indirect losses (e.g., decline in revenue, business interruption). Some will

also count these losses at the community, state, regional, or global levels, depending on the nature and impact of the hazard event" (Gall et al. 2009).

Impact assessments conducted on a regional or national scale are often too general to capture the unique ramifications felt by a given sector, like a particular port stakeholder cluster. Thus, there are also many ways to categorize impacts on a local or regional scale. Short-term vs. long-term costs, reported vs. unreported losses, breakdowns by "who pays," and costs by geographic area are but a few. The Heinz Center report, *The Hidden Costs of Coastal Hazards* (2000), recommends a combination of quantitative estimates when data are available and qualitative descriptions when they are not. It suggests breaking down costs by economic sectors such as: housing, commercial and industrial property, or transportation infrastructure. However, as the report points out, many of these costs are hidden and/or very difficult to quantify due to the lack of data. Damage assessments, typically conducted on a particular property, focus on the actual damages to the property, but do not account for the indirect costs and intangible consequences resulting from that loss that impacts the broader community.

Impact assessment and risk identification methods typically do not allow for a detailed understanding of how storms might impact clusters of stakeholders who depend on a given piece of infrastructure, such as transportation, utilities, or seaports. Some assessments may be too broad in geographic scale (Lian et al. 2007; Hallegatte 2008) to inform relevant local decision makers, while others may focus on one projection of one particular cost, such as insured losses (Grossi et al. 2005) or direct damage to structures (Curtis 2007; LADOT 2006). Further, many traditional ways of assessing direct damages and indirect costs may only be applied post factum. They are designed more for looking at "what happened" and using costs for repairs and insurance claims to quantify damages. This case studies presented here provide the type of richer

understanding of the full range of potential impacts that can lead to better resilience planning for ports (Woodroffe 1990; IPCC 2012; Stern and Britain 2006).

2.5.1. Challenges in seaport resilience and adaptation planning

Due to the projected impacts of climate change, planning for seaport resilience has recently emerged as a unique area of resilience research (McEvoy and Mullett 2013; EPA 2008; Becker et al. 2013), in addition to a variety of other infrastructure sectors such as roads (NRA 2012), airports (Baglin 2012), railways (Baker et al. 2010), and infrastructure as a general concern (NIAC 2009). A new body of work has begun to address a need to shift planning paradigms to include a range of incentives and more stakeholders in the process of creating more resilient ports (Ng et al. 2013; Becker et al. 2013).

However, understanding the magnitude of port resilience issues is still in its infancy and the scope of the problem for ports and port stakeholders is still not well understood. Little guidance is available for incorporating long-term resilience (more than 20+ years out) in the port infrastructure planning process in the U.S. or elsewhere in the world. Further, ports also fall outside of the planning parameters that regulate other types of coastal uses. Ports are typically zoned for industrial use and thus are not subject to many regulations that are designed to protect the interests of residents. For example, U.S. Executive Order 11988 (Floodplain Management) requires federal agencies to prevent long and short-term adverse impacts associated with the occupancy and medication of flood plains, and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative (FEMA 2013). However, since FEMA considers ports to be functionally dependent infrastructure that must be located in a floodplain,

requirements can often be relaxed for port infrastructure.[1]

The U.S. has no centralized authority that oversees investment or operation strategies for ports that provides guidance or incentives for resilience planning. Further, oversight is more difficult, due to the port ownership structure, which may be any combination of public and private, ranging from those that are 100% privately owned and operated, to public/private partnerships, to those that are 100% publicly owned and operated. Since the port operator has a direct interest in the ongoing functioning of the port, one might expect to find storm resilience addressed in the port's strategic planning process, which for ports is typically based on the core mission and principles of a port operator (Allen 2012). However, ports generally plan in accordance with three time horizons that do not align well with climate change projections (Dooms et al. 2004):

Short-term planning covers a one-to-three year time span with a primary focus on operational issues and current practical problems.

Medium-term planning covers three to five years and typically focuses on marketing and financial goals.

Long-term planning typically covers a 10 to 25-year time horizon and focuses on the development of the wider port area.

It is usually difficult for a port operator to develop concrete plans and strategies for infrastructure development beyond 25 years, since too many assumptions would have to be made about factors such as employment, cargo throughput, and technological advancements. Climate change, and the accompanying increase in risk from extreme events, requires a longer planning horizon.

[1] Note that this gap is being addressed in part through the recent *Presidential Policy Directive 21 – Critical Infrastructure Security and Resilience* that establishes a national policy to strengthen and maintain secure, functioning, and resilient critical infrastructure.

Discussions with port planners have affirmed that resilience issues are not typically a part of the strategic planning process (Pers. comm. Kiernan). This may be in part because of a lack of an appropriate incentive structure. As stated by the National Infrastructure Advisory Council, "Current market mechanisms may be inadequate to achieve the level of resilience needed to ensure public health, safety, and security. Even with a strong business case, there are low-probability, high-consequence events for which investments in resilience by private companies cannot be justified" (NIAC 2009). To raise capital for expansion or improvements, ports rely on a combination of their own profits and public assistance on an ad hoc basis (ASCE 2012). However, even without factoring in climate change, a recent report projected a GDP loss of $697 billion by 2020 unless significant investments are made into the Nation's marine transportation system (ASCE 2012). Although climate change is already affecting some areas, noticeable changes that will impact infrastructure are not likely to become evident for several decades from the present (USCCSP 2008), a time horizon well outside of strategic planning processes designed to maximize profit.

This section provided background on the key concepts that underlie this research. These concepts include climate adaptation, seaport resilience, the stakeholder cluster, and impact assessments. The next section provides the background and context for the case studies. It begins with an overview of the reasons for selecting Gulfport and Providence as case studies. It then provides background and context for each of the two ports. Finally, the methods used for interviews and the documents selection, the creation of storm scenarios as a thought prompt, as well as the analysis are described.

3. Case study description and data collection methods

This study considers two seaports that are highly exposed to hurricanes in which stakeholders have been engaged in resilience planning (Figure 4). The Port of Gulfport (MS) recently experienced the devastating consequences of Hurricane Katrina and has been in the process of rebuilding. Providence (RI) has not had a major hurricane since 1954, but is similarly exposed to potential storm surges in excess of 25'. The decision makers in Providence and statewide in Rhode Island have been involved with two principal climate adaptation efforts: a new part of the Rhode Island Coastal Resources Management Program addressing adaptation to natural hazards; and the formation of a Climate Change Commission. We undertook the case studies of these two ports to focus on problem identification at the local level. Because our main interest and focus was on questions about impacts and resilience, we selected these ports because of their high exposure to hurricanes and because stakeholders were likely to be familiar with resilience planning. Both ports are small to medium sized and provide jobs, goods, and services to their local economies and communities.

Figure 4 -- Map of Gulfport and Providence

3.1. Overview of Gulfport

Gulfport, Mississippi, faced utter destruction from a 28' storm surge during Hurricane Katrina. Gulfport had recently adopted a plan to elevate the entire port from 10' to 25' as a strategy to build the port's resilience to Katrina-magnitude storms. This $140m investment in resilience was unparalleled. No other port that we researched had considered such a drastic step toward storm resilience. Thus, we selected Gulfport because we anticipated a high degree of awareness around the impacts of hurricanes (due to the recent Katrina event) and the potential resilience-building

strategies.

The Port of Gulfport (Figure 5) is Mississippi's largest port and the third busiest container port on the U.S. Gulf Coast. It imports fruit, garments, limonite ore, and hardwood lumber, and it exports paper, cellulose, fabrics, and other products. Primarily a container port, Gulfport handled 216,000 twenty-foot equivalent units (TEUs) in 2011 (Table 1). A chief executive officer and five port authority commissioners oversee the port operations under the auspices of The Mississippi Development Authority (MDA) and the Mississippi State Port Authority at Gulfport (MSPA). The mission of the port is "to be a profitable, self-sufficient port providing world-class maritime terminal services to present and future customers and to facilitate the economic growth of Mississippi through the promotion of International trade and the creation of employment" (PEER 2006)

Figure 5 -- Aerial view of Port of Gulfport (www.portofthefuture.com)

Table 1 -- Port of Gulfport statistics

Gulfport has been hit by 25 hurricanes since 1858, with 9 of them being major (i.e., Categories 3, 4, or 5) (Figure 6). The National Oceanic and Atmospheric Administration (NOAA) estimates a return period of 11 years for a hurricane hitting Gulfport (Blake et al. 2011). The port is very exposed to open water and sits in the hurricane "catcher's mitt" of the Gulf Coast, where storms tend to track after passing through the Gulf of Mexico.

Figure 6 -- Hurricane tracks near Gulfport

On August 29, 2005, Hurricane Katrina made landfall as a Category 3 storm that brought storm

surges of up to 30' to Gulfport (Fritz et al. 2008). Katrina devastated much of the Gulf Coast, leaving almost 2000 people dead and causing $81B in damages (Knabb et al. 2005). In the City of Gulfport, the surge flooded six to twelve miles inland (Fritz et al. 2008). Direct damages to the port itself were estimated at over $50 million (Table 2). During that storm, gaming barges, a gantry crane, and 430,000 square feet of warehouses and freezer facilities were demolished. Another 400,000 square feet of enclosed warehouses, parking structures, and fill material were severely damaged. The public at large experienced losses due to the direct impacts of the port's physical contents (containers, poultry, etc.) and also due to the indirect impacts of the port's loss of business and operational continuity. The loss of business continuity resulted in rising prices, difficulty in obtaining materials, unemployment, and strain on other parts of the transportation system. The loss of operational continuity left many important resources unavailable. For example, the severe damage to Gulfport resulted in regional shortage of tropical fruits, because major fruit importers such as Dole, Chiquita, and Crowley were forced to reroute shipments to Port Everglades, FL, or Freeport, TX, at extra expense (USCCSP 2008; Grenzeback and Andrew). The local and regional economy suffered when the operations at the port shut down after Katrina due to the loss of jobs, taxes, and an increase in prices.

Table 2 -- Assessed damages to the Port of Gulfport (PEER 2006)

3.1.1. The plan for restoration of The Port of Gulfport

After Katrina, the MSPA, Governor Haley Barbour, and the MDA weighed options for developing a more resilient port, ultimately choosing a strategy to elevate the port (see Table 3). However, the roots of this plan lay in a pre-existing master planning effort to expand the port in anticipation of new business that would come from the widening of the Panama Canal. Before

Katrina, the MSPA had already initiated an 84-acre port expansion program. 60 acres of the Mississippi Sound had been filled in before Katrina hit, leaving an additional 24 acres still to fill. This expansion plan was to be funded entirely through state bonds and port revenue and would increase business opportunities for the port. After Katrina, the Governor charged the MSPA with the task of developing a new strategy for resilience and the MDA with managing the funding of the project. The MSPA hired the JWD Group, an engineering consulting firm, to revise a 2003 master plan that addressed new development opportunities for both maritime and non-maritime uses in downtown Gulfport. The new revised plan also incorporated resilience measures that piggybacked on a pre-existing inland port distribution-center concept; at a cost of approximately $130m, an inland port three miles from the coast would also serve as a freight evacuation depot under any significant hurricane threat. Though this evacuation plan was incorporated in the 2007 Master Plan Update, it included no explicit discussion of future hurricane risk, or about the importance of storm resilience at the port itself. A detailed visioning section focuses only on land-use goals and port expansion (MSPA 2007).

Table 3 -- Timeline for port resilience strategies in Gulfport

After completing the 2007 Master Plan Update, the MSPA contracted CH2M Hill, an engineering consulting firm, to implement and manage the project, which began with a review and comment of the updated plan. CH2M Hill found that the evacuation plan was, “an enterprise limiting constraint, as well as an unquantifiable business risk to potential facility users. To put all containers at an off-site location increases the cost of shipping, thereby making the Port of Gulfport less attractive and less competitive to maritime carriers” (CH2M Hill 2010). CH2M Hill recommended a radically different approach. Rather than relying on a plan to evacuate the port every time a hurricane approached the Gulf Coast, they suggested elevating the entire port from

10' above sea level to a 25' above sea level. The Governor and MSPA agreed and the MSPA and MDA undertook a revision of the project's Environmental Assessment Report to include the new elevation strategy.

In their plan, they stated two main reasons for the new elevation plan:

1. To protect facilities, equipment and cargo against storm surge;

2. To minimize disruptions to the Port tenants by eliminating the need to fully evacuate the terminal in the event of an approaching storm.

This improvement to the Port's facilities would serve as a benefit and potential lure for new customers. No other port on the Gulf Coast offers such hurricane surge protection (CH2M Hill 2010). CH2M Hill and MSPA convened a "council of experts" to assess the design feasibility of raising the container laydown area, while keeping the ship loading/off-loading at its current elevation, ultimately proposing a series of ramps between the two heights. CH2M Hill estimated the cost of elevating 140 acres from 10' to 15' to be approximately $140m, or $1m/acre (CH2M Hill 2010). Through the Federal Department of Housing and Urban Development (HUD), the State of Mississippi applied for and received a "Community Development Block Grant (CDBG) Disaster Recovery Program" grant in the amount of $621m to "rebuild and restore the damage to its facilities caused by Hurricane Katrina. The allocated funds would assist in providing mitigation against future damage, prevent future recurrence of damage and destruction in Hurricane events, and provide the long-term recovery of the operating capacity of the Port" (MD 2011).

Once the decision to elevate the port had been made, an Environmental Assessment Report (EA), as required by HUD, became the main mechanism for ensuring organizational checks, balances, and involvement in the project. Since HUD provided the bulk of the funding, it served as the lead

organization for the environmental review process. However, the MDA served as the "responsible entity" and prepared the EA, together with the MSPA. The EA process required the input of numerous other agencies (Table 4). However, the EA did not require any specific external review of the port elevation component of the project.

Table 4 – Organizations consulted in Gulfport's Environmental Assessment for port restoration

The MSPA planned to complete the "Restoration Program" project by 2017, but in 2012 decided to significantly downscale the elevation component of the plan in order to bring the port back online more quickly. As of the writing of this paper, the MSPA was weighing "no additional elevation" vs. "additional two-to-four foot elevation" alternatives (MSPA 2012).

3.2. Overview of Providence

At the time this research was conducted, the Port of Providence, a private service port (For a discussion of types of ports, see PPIAF 2013), supplied a large part of Connecticut, Massachusetts, and Rhode Island states with petroleum products and handled bulk and break-bulk imports and exports. Home heating oil, jet fuel, diesel, and other petroleum products were imported through Providence Harbor. Numerous ancillary businesses also depended on the port's functionality, including: trucking companies, rail service, manufacturing companies, ship repair facilities, marine pilots, and dredging companies, and even the State's airport, which depended on the port for jet fuel. The Port also sat at the head of Narragansett Bay, an ecologically sensitive estuary that provides breeding grounds for marine life in the region. 105 acres of port

lands were owned by the City of Providence and operated by a five board member nonprofit organization, ProvPort. However, ProvPort leased the land to and contracted the services of Waterson Terminals LLC, to operate and maintain the port. However, the full area of the Port of Providence comprises a number of other waterfront businesses and industries, which together, took up nearly 230 acres of waterfront (Becker et al. 2010). In 2010, the Port of Providence handled approximately 3.1 million tons of cargo. ProvPort generated more than $200 million in economic benefits for the region and over 2,400 jobs were attributed to port activities (PWWA 2010). ProvPort itself handled a variety of products, including scrap metal, wood products, coal, salt, cement, and chemicals. There was no official port authority in Rhode Island and the State played no direct role in port operations, though the state's coastal agency does regulate land use in the coastal area that the port occupies.

For the purpose of these case studies, we consider the "port" to encompass the entire port district (Figure 7), even though Waterson Terminal Services is referred to as the *Internal Port Stakeholder* for the purposes of this research. Since Rhode Island had no official port authority that oversees operations or the development of the port area in Providence, there was no centralized planning body that considered storm resilience issues. Even though Waterson Terminal Services oversaw the operation, maintenance, and planning for the terminals of ProvPort, they functioned more autonomously than a port authority, such as the one in Mississippi.

Figure 7 -- Providence Harbor and its water dependent uses (Becker et al. 2010)

The Federal Emergency Management Agency (FEMA) considers Providence to be the "Achilles heel of the Northeast" due to its position at the head of Narragansett Bay (Rubinoff 2007). For

context, before Hurricane Katrina caused $80 billion in damages to the Gulf Coast, FEMA considered New Orleans to be the Achilles heel of that region. Rhode Island had been hit by nine hurricanes, two of them major, since 1900 (Figure 8). The length and orientation of Rhode Island's Narragansett Bay, and its proximity to the Atlantic hurricane zone, make it susceptible to extreme storm surges from the southerly winds that are generated when a hurricane passes to the west of the Bay. The U.S. Geological Survey currently considers the probability of a storm hitting this area as "low" (Rubinoff 2007). A recent study estimates the hurricane return period for Rhode Island to be 24 years, with the "major" hurricane return period of 94 years based on historical data (USGS 2010). The Bay had not experienced a significant hurricane since Hurricane Carol in 1954, which produced 14.5' of storm surge. Models for hurricane effects in Providence projected storm surges of over 20', but these do not include climate change projections for sea level rise or the intensification of hurricanes (Blake et al. 2011). Most of the port lands are 3-10' above mean high water. There is a hurricane barrier in place, but the barrier is north of the port and could cause higher storm-surge levels at the port, as surge waters would accumulate in Providence Harbor instead of spreading throughout the low-lying region now protected behind the barrier.

Figure 8 -- Providence and history of storm tracks

3.2.1. Adaptation planning in Rhode Island

As we began this research, Rhode Island was in the midst of undertaking adaptation planning efforts for the State. The Coastal Resources Management Council (CRMC), together with the Coastal Resources Center (CRC) at the University of Rhode Island (URI), had been drafting new sea level rise policies and a new *Hazards Chapter* for the State's Coastal Resources Management

Plan. These policies provide broad guidance for adapting to new sea level rise, including recommendations for altering building codes. The Climate Risk Reduction Act of 2010 (RIGL 23-84) established a new Rhode Island Climate Change Commission (RICCC 2012), with a mandate to study the potential impacts of climate change in the State, and identify methods to adapt to these changes in order to reduce harm and increase economic and ecosystem sustainability. The RICC would also identify ways that adaptation could be mainstreamed into existing state and municipal programs (e.g., policies, plans, infrastructure development). At the time we conducted interviews, this Commission had not yet convened. In Rhode Island, planning efforts such as these often involve a relatively small pool of decision makers, as Rhode Island is a very small state. The lead author's experience working on such planning and policy efforts in the state indicated that many stakeholders of the port cluster would also have some awareness or involvement in these planning efforts.

3.3. Data collection and interview methods

The case studies were designed to identify the ways in which port stakeholders perceive the impacts of a hurricane occurring at the port, the ways that planning/policy addresses those concerns, and the potential strategies for building port resilience.

These studies assessed two sources of information about impacts of a hurricane on the Port of Providence, RI and Gulfport, RI: interviews that clarified the perceptions of port stakeholders and policy documents that address storm issues at the port. The interviews of port stakeholders show the concerns of stakeholders about potential impacts that may or may not be recognized through the more formalized planning and policy-making process. The analysis of policy documents reveals how decision makers formally recognize the potential impacts of a storm

hitting the port. By utilizing both of these sources, a richer picture of the range of impacts and strategies emerged, as well as indications of disconnects between the stakeholders' concerns and the current policy.

We carried out surveys in these two ports over the summers of 2010 and 2011 during two visits to the Port of Gulfport and three to the Port of Providence. During these visits, we conducted the interviews of stakeholders, collected policy and planning documents, and visited the ports themselves and other organizations where the interviews were conducted.

3.3.1. Selection of interviews

For the purpose of this study, we consider the seaport stakeholders as a *cluster* that includes all of the organizations that could or should play some role in the decision-making regarding long-term storm resilience for the port. We selected stakeholders using a snowball sampling approach (Chermack 2004; Cairns et al. 2012; Patton 2002) that resulted in an approximation of each of the seaport clusters. Beginning with the port managers, we asked respondents:

What other organizations could play a role in port resilience planning, and to whom, in the respective organizations, should we speak to about these issues?

As noted above, the stakeholder of the port could include every citizen in the State of Rhode Island or Mississippi and beyond, and number in the hundreds of thousands. We thus limited the cluster to those organizations that could play a role in resilience planning for the port, as indicated by the stakeholders themselves. When no new names or organizations were added to the suggested list by the interviewees and attempts had been made to interview the organizations mentioned, the sample was deemed complete. Named individuals were contacted, given a brief

explanation of the project, and subsequently interviewed. In almost all cases, the named individual agreed to be interviewed or designated another individual within the organization who did.

In Gulfport, the 30 interviewees included five internal port stakeholders, three external economic/contractual stakeholders, nine federal public policy stakeholders, nine state public policy stakeholders, three local public policy stakeholders, and one community group stakeholder (Table 5). Both the MDA and MSPA were considered to be internal port stakeholders, rather than state agencies, because both are directly involved in the port planning and operations. The federal and state governments featured prominently, mostly because a state port authority operates the Port and the Katrina rebuilding efforts depended on federal funding. We were unable to interview representatives from the U.S. Customs, the State Senate, the Environmental Protection Agency, and Kansas City Southern Railroad. Other interviewees mentioned these stakeholders, but we were unable to identify a specific representative who could speak to the issues of hurricane impacts to the port. No academic/research stakeholders were suggested in Gulfport.

Table 5 -- Stakeholders interviewed in Gulfport

In Providence, 27 interviewees included three internal port stakeholders, five economic/contractual stakeholders, one community/environmental group stakeholder, three academic/research group stakeholders, four federal public policy stakeholders, eight state public policy stakeholders, and three local government public policy stakeholders (Table 6). We were not able to interview representatives of the Oil Heat Institute, some of the private companies within the port area, or the Rhode Island Marine Pilots Association

Table 6 -- Stakeholders interviewed in Providence

3.4. Storm scenarios

In order to help interviewees think about storm events with respect to the port, we presented respondents with a plausible, potentially catastrophic storm scenario as a visual prompt. This scenario method has been successfully used in other studies on climate change to engage stakeholder groups and inform policy makers (Chermack 2004; Cairns et al. 2012). We created storm scenarios together with Applied Science Associates (Rhode Island) who developed the storm surge overlay for the visuals. Three students (Suejung Shin, Ernestine Fu, and Akshay Adya) helped develop 3D models to represent the structures of (or in) the port. The resulting visual scenario was a combination of a map of the port area, overlaid with a storm surge image, equivalent to an approximately Cat 3 (Gulfport, see Figure 9) or Cat 4 (Providence, see Figure 10) hurricane, with an additional 1.6' added for anticipated sea level rise. The scenario depicted a map of the port area overlaid with the resulting storm surge. In Providence, this represents the expected surge from a Category 3 hurricane that passes just west of Narragansett Bay, producing approximately 26' of surge.[2] In Gulfport, this represents a Category 4 storm that produces approximately 30' of surge.

Figure 9 -- Port of Gulfport with simulated Category 4 storm surge

Figure 10 -- Port of Providence with simulated Category 3 storm surge

[2] The surge heights were derived from NOAA's Maximum of Maximum Envelope of High Water, which is a worst-case scenario storm surge from a given hurricane. For more information, see http://www.nhc.noaa.gov/ssurge/ssurge_momOverview.shtml. We added 0.5m (1.6') of sea level rise, a low-end projection for 2100.

3.5. Interviews with stakeholders

We conducted semi-structured interviews individually as much as possible, though in some cases two or three people attended an interview. In these cases, transcripts were coded to record the responses from each individual separately. Interviewees were assured that their identities would remain anonymous and that quotes from their responses would not be identified and attributed to them individually. We designed a questionnaire using (Moser and Ekstrom 2010) as a template (see Becker 2013) as it was also designed to interview stakeholders about plans and perceptions around climate adaptation and resilience issues. Using the storm scenario as a thought prompt, the purpose of the questionnaire was to elicit *perceptions of storm impacts*, *current and potential strategies for reducing port vulnerability to storms*, *perceptions of planning processes and barriers to reducing vulnerability*, and *perceptions around climate change and climate change adaptation*. We tested the questionnaire through six mock interviews with fellow students and experts in the field and revised questions that were unclear. The present study focuses on the first two areas of inquiry in the questionnaire (impacts of storms and resilience strategies). Questions probed the respondents' perspectives on these issues, as well as on their management responsibilities with respect to the port. For each of the 30 questions, we also provided potential follow-up prompts to help generate further detailed discussion. Not all questions however, were covered in each interview. Interviews focused on the subjects that matched the interviewees' knowledge and expertise. Thus, questions not relevant to the interviewee were skipped. Respondents were encouraged to think broadly about the port, the role it plays in the community, and the full range of hurricane impacts and strategies that could build resilience, including both short and long term possibilities that could be implemented by their own organization or others. Respondents in both case studies discussed both the strategies that were already being followed

and those that could be implemented in the future. If they had trouble responding to the questions, some follow-up prompts were used to stimulate the conversation (refer to full questionnaire in Becker 2013). Though it came up in interviews, we did not provide a definition of resilience, thus allowing the interviewees to consider this concept in a way that was most meaningful from their organization's perspective. In Gulfport, for instance, many respondents referred back to their experience with Hurricane Katrina. Although five years had elapsed since the storm and the interviews focused on hurricanes in general, Hurricane Katrina remained a strong theme. The interviews were digitally recorded and transcribed by either myself or through a hired transcription service.

3.6. Document collection

In order to examine how stakeholders' perceptions were reflected in formal port planning and policy documents, we also examined the documents that address storm impacts and/or long-range resilience plans for the case study ports. We identified planning documents for the states and cities, hazard mitigation plans, storm planning documents for individual businesses, economic development plans, and others that we felt might possibly include references to port resilience planning or the impacts of hurricanes on the Port. Through web searches and suggestions received from the stakeholders during the interviews and through follow-up requests, we examined the 16 documents from Providence and 32 from Gulfport that we expected might address storm impacts and/or long-range resilience plans for the port. We searched the collected documents for the following keywords: "[**name of the case study port**]" and "**port** or **seaport** or '**maritime infrastructure'**" and "**hurricane** or **storm** or **hazard**." We eliminated documents if they did not address these search terms, were not officially

published/released, or were not policies actually in use by a port stakeholder.

Of the 32 documents collected and reviewed in Gulfport, 16 met the search criteria (Table 7). These included numerous planning documents from the Mississippi State Port Authority (MSPA), as the MSPA was in the process of an expansion and redevelopment process after Katrina. We also reviewed hurricane plans, economic impact assessments for the port, the testimony of Governor Haley Barbour in which he appealed for disaster recovery funding, and the impact assessments for the region.

Table 7 -- Documents reviewed from Gulfport

Of the 16 documents collected and reviewed in Providence, six met the search criteria (Table 8). The Port itself had no documents that specifically addressed storm resilience, outside of a hurricane plan that we were not able to review formally. Interviewees, however, described this as a standard operating procedure for securing the port facility in advance of a storm and not a long-term planning document. Representatives from the port informed me that planning was generally completed on a task basis and contracted out to consultants, thus there was no master plan or strategic plan for the port. The most detailed of the plans in Providence, is the Hazards Chapter draft that would ultimately be a part of the Coastal Resources Management Program. This plan also drew from a student report on debris that had been conducted at URI (Spaulding et al. 2007). We did not include this student report in the analysis, as it was not an official planning/policy document.

Table 8 -- Documents reviewed in Providence

3.7. Coding method

Following transcription, the interviews and documents were coded and analyzed using the NVivo qualitative data analysis software package. The analysis used an *analytic induction method* described by Ratcliff (1994) as an iterative process that allows for themes and ideas to become evident through the coding process, also allowing for the modification of concepts. An example of this process, in this case for coding impacts of a hurricane event in Providence, is shown in Figure 11. The following steps summarize the coding process:

1. *Line by line review*. In total, 955 pages of interview transcripts from Gulfport and Providence were reviewed line by line. Planning and policy documents were reviewed

through the use of key word searches for relevant content (e.g., storm, hurricane, impact, damage, port, etc.) and a review of the pages surrounding these key words.

2. *Identification of the idea to be coded* (e.g., impact or strategy mentioned). A first round of coding was performed on transcripts and documents to identify initial impacts and strategies (Charmaz 2006). Key phrases and ideas were tagged, grouped, and ultimately distributed into broad categories and more specific subcategories.

3. *Creation of key phrase to group main ideas*. A second round of coding was conducted with more attention to details and resulted in a variety of subcategories for both impacts and strategies.

4. *Creation of subcategories* to group main ideas identified in Step 3.

5. *Group into main categories*.

Figure 11 -- Method of coding

As we developed subcategories, we continued to review the transcripts to ensure that all relevant ideas were captured and categorized appropriately. Coding was an iterative process and ultimately the documents and transcripts were reviewed numerous times. An inductive approach was used to create the subcategories, followed by a deductive approach to group them into three main impact categories described in detail below.

3.8. Three impact types

The results of the interviews and documents were coded and bundled into the impacts categories defined by the IPCC. We use the IPCC's (2012) definition of ***impact*** as an umbrella term to capture both the *direct damage* to a given port facility as well as the various *indirect costs* and *intangible consequences* (economic or otherwise) of that damage (Figure 12). Thus, ***impacts*** include three main subcategories, as follows:

Direct damages refer to damages that occur at the time of the weather event and are a direct result of it, such as damage to structures, infrastructure, and property.

Indirect costs are the "reduction in production of goods and services, measured in terms of value added" (Hallegatte 2008). These include losses associated with the disaster that occur in the weeks, months, or years following the event. They also include losses or gains in wages, changes in profits, and decrease or increase in production. Models that quantify indirect costs often use industry input/output tables, but since they rely on regional data, the technique is difficult to apply to one specific facility, like the port (Cochrane 2004).

Finally, *intangible consequences* include many non-market consequences of disasters. Examples include: loss of life, health impacts, ecosystem damages, and damages to historical and cultural assets. These consequences of the disaster, sometimes called high-order losses (Rose 2004) or hidden costs (Heinz Center 2000) are very difficult to characterize and quantify as there are often no economic measures available for evaluation.

Naturally, some impacts have a cascading effect. For example, damage to a crane (*direct damage*) can result in expenses from cargo being re-routed (*indirect cost*) and/or that cargo being unavailable to consumers in the short term (*intangible consequence*).

Figure 12 -- Hurricane impacts on port stakeholders

Every attempt was made to assign each "impact mention" to a single "impact type" and category. This proved to be straightforward when interviewees were explicit about a given impact. In some instances, however, an "impact mention" fell into multiple "impact types." For example, a mention of *shipping containers being washed up throughout the City* has a quantifiable *indirect cost* element (e.g., a fixed cost to remove a container from a residential property) and an unquantifiable *intangible consequence* impact (e.g., psychological ramifications of a resident living with a shipping container on their front lawn). When not explicit, we based coding on our

best interpretation given the context. We aimed to be as specific as possible about given impacts and thus allowed some impacts that might be conducive to grouping to remain distinct and separate. For example, a subcategory of *Disruption of critical services*, could have captured the following more specific items: *Destruction of energy infrastructure, Disruption of regional energy distribution, Interruption of critical goods supply, Interruption of essential services, and Interruption of power supply*. However, our intention was to allow this to be a fine-grained analysis, thus we kept these somewhat similar impacts distinct.

For each impact, we also assessed whether the cost would likely fall upon the "internal stakeholder" (i.e., the port operator) or the "external stakeholders" (i.e., one or more of the other stakeholders that make up the cluster) or both. The purpose of this cost assessment was to examine how the range of impacts distributes across the stakeholder cluster. We assessed cost burdens based on the management responsibilities described by respondents in interviews, as well as a review of organizational mission statements, jurisdictions and mandates (Becker 2013). We use the concept of "bearing the cost" broadly, as some costs may be easily determined (e.g., the cost to repair a structure), while others may be more difficult (e.g., cost of lost business), or not easily quantifiable in economic terms at all (e.g., environmental costs of an oil spill). Though this is a subjective exercise, it offers an initial assessment of how these impacts are distributed across the stakeholder network. Finally, we noted which impacts were mentioned in interviews and which were mentioned in documents in order to examine how the impacts were addressed through planning and policy (for more on stakeholders interviewed and documents reviewed, see Becker 2013).

4. Results

The preceding section set the stage for the analysis of interviews and documents. Next we discuss the results for each of the three categories of stakeholders and how the costs distribute across the cluster. We first provide an overview of the results in aggregate and then details for each of the three broad impact types with examples from Gulfport and then from Providence.

In total, we identified 106 distinct impacts through our review of all 57 interview transcripts and 22 planning/policy documents (Figure 13). Through the analysis of 30 interview transcripts and 16 document reviews in Gulfport, we found 253 total "mentions" of 78 distinct impacts. In the analysis of the 27 interviews transcripts and six documents in Providence, we found 138 total mentions that we grouped into 46 distinct impact types. The highest number fell into the "intangible consequences" category, followed by "direct damages," and finally "indirect costs."

Figure 13 -- Unique impacts mentioned in Gulfport and Providence

In each of the three sections below, a table depicts the unique impacts mentioned. For each case study, these tables show from which type of data source the impact was mentioned, as follows: Impacts mentioned in interviews only show an "I," those found only in documents show a "D," and those impacts mentioned in both documents AND interviews show a "B." In this study, we do not venture too deeply into the linkages between impacts, nor the specific cost amounts that could arise should the event occur. However, we do also examine which stakeholders would likely bear those costs in order to provide a frame of reference for which groups have the most to lose. Cost burden for each stakeholder group, indicated by a "$" in the Table 9 and Table 10, shows that there is likely a monetary cost for that particular stakeholder group. In Table 11, a checkmark is used, as many of the costs associated with *intangible consequences* are difficult to

monetize.

4.1. Direct damages

Direct damages refer to damages that occur at the time of the weather event and are a direct result of it, such as damage to structures, infrastructure, and property. These are shown in detail in Table 9.

Table 9 -- Table of direct damages

4.1.1. Gulfport direct damages

The interviews and documents from Gulfport combined contained 128 total mentions of 30 unique direct damages. These include many damages experienced at the port itself, as well as damages to the surrounding area that result from events at the port. Though interviewees were provided with the future storm scenario, they tended to refer back to their experience with Katrina. Thus, most of the direct damages mentioned were descriptions of actual events, rather than perceptions about what could happen during the next event. Many direct damages also result in downstream indirect costs and intangible consequences, which will be addressed in subsequent sections, as tracing those pathways in detail was beyond the scope of this study.

In interviews, many respondents focused on *Damage caused by debris off port property*, which refers to the containers and cargo that were washed off port property during Katrina. Twelve of the interviewees talked about these issues in terms of the direct damage associated with debris. Some aspects of this debris problem are easily quantified in monetary terms, such as the cost of cleanup or the damage to a building caused by a piece of debris. However, as subsequent sections will show, the impacts of debris are cross cutting and also include indirect costs, and

intangible consequences. Some debris damaged the port itself, but much of it originated from the port and resulted in other types of impacts throughout the city. Interviewees described how, during Katrina, the storm surge completely submerged the port, containers floated freely, industrial rolls of paper ended up on the second story of the parking garage, warehouse contents were scattered throughout the surrounding neighborhoods, and the structures on the port itself suffered enormous damages due in part to debris. Shipping containers in particular caused extensive damage. One respondent described containers surfing down the faces of waves, and "*flying into neighborhoods, breaking up houses that may have been repairable from flooding alone, but instead were just pulverized.*"

Nine respondents, most from the port or port businesses, also recounted a variety of direct damages to port property itself, including gantry cranes, warehouses, piers, and utility lines that Katrina completely destroyed:

> *[The port] was flattened. There was nothing here. Our berth collapsed . . . Eight weeks later, the channel was okayed [and] later they finally brought a ship in, but it was of course restricted to daylight only ... The infrastructure was completely gone.*

Direct damages to freight and cargo referred to cargo and freight, but interviewees spoke about it more as a cause of damage (as debris) than as a loss in and of itself. In the context of the level of damage and costs of cleanup, the monetary loss associated with a cargo of poultry products or some industrial rolls of paper was probably quite minor and likely covered by insurance. Like all ports, Gulfport depends on a transportation network that includes road and rail. Though two of the documents reviewed mentioned general damage to the on-port rail lines, interviewees did not discuss *damages to road and rail* specifically. However, we were not able to speak with a representative from the Kansas Southern Rail Company.

The planning and policy documents we analyzed focused on direct damages at the port in great detail. A damage assessment undertaken by the Mississippi State Port Authority (MSPA) consisted of an extensive survey of the port property conducted after Katrina, that assessed the level of damage to all buildings, piers, wharves, and equipment at the port (MSPA 2005). The repair and rebuild estimates from this assessment were used both for insurance claim purposes and as a work list for the MSPA. The report notes 22 unique damages to the eastern and western piers. Items included debris fields under the piers, building foundation damages, building topside damages, total destruction of buildings, damage to railways, and damage to utilities.

The costs of repairs for direct damages fall primarily upon the internal port stakeholders, though many such costs will also be paid by the economic/contractual stakeholders who conduct direct business with the port. Port tenants, for example, could bear the costs of repairs to their buildings and equipment, utilities (e.g., the cost to replace electric service to refrigerated storage containers), or damage resulting from flooding. Many of these direct damage costs result from repairs and cleanup. In the case of Katrina, the port tenants and insurance companies paid for some of the damages mentioned, though interviewees did not discuss specifics. In addition, the Federal Government provided funding for both repair and rebuilding/expansion of the port through both FEMA ($60 million) and Community Development Block Grant funds (approximately $560 million). Numerous indirect costs and intangible consequences, however, also result from these direct damages. Those are discussed in the following sections.

4.1.2. Providence direct damages

In Providence, a total of 15 distinct direct damages were mentioned cumulatively in interviews and in the planning and policy documents. Twelve of these were mentioned in interviews, but

only three were mentioned in the planning and policy documents.

Most of the impacts mentioned in Providence referred to potential damages to port property, either to structures or equipment or to the wharves and berths at the port. The petroleum fuel tanks located in the port area stood out as a major concern amongst those interviewed. Concerns about the tanks included damage to the tanks themselves, spills, and even the possibility that with enough storm surge, the tanks might float off their bases. These damages to tanks could have major repercussions for the region, as they could also result in both indirect costs (e.g., cleanup costs) and intangible consequences (e.g., environmental harm from fuel spillage). One respondent illustrated his concern by telling an anecdote about the last major storm some 55 years before:

> *We've got big time problems down in the port as far as hazards are concerned. In 1954 we had hurricane Carol come through here … petroleum tanks went floating down Narragansett Bay because the storm surge that came up flooded out the low lying areas of the port.*

Almost all of these direct damages would likely result in some or all of the costs being borne by the port itself, though others, such as *damage to vessels and barges* would likely be covered by external stakeholders, mainly grouped in two categories: the economic/contractual stakeholders who are tenants at the port and the stakeholders who do business directly with the port (e.g., insurance companies, shipping companies, rail lines). Many such damages would likely be covered through insurance policies, unless the damage far exceeded the amount covered, however we were not able to review the specific insurance policies to ascertain which specific damage items would be covered. The Federal Government, through disaster relief funds would also likely cover some cleanup and rebuilding costs. Other stakeholder in the cluster, such as the local public policy makers and the community groups, would probably not be responsible for the

costs associated with direct damages. Although most costs associated with direct damages would fall primarily upon the internal port stakeholders, many indirect costs and intangible consequence costs that result from these direct damages would be shouldered by external stakeholders, as shown in the subsequent sections.

4.2. Indirect costs

Indirect costs are the "reduction in production of goods and services, measured in terms of value added" (Hallegatte 2008). These impacts *could* be quantified in economic terms, although special models or techniques would be required to do so. Table 10 details these unique impacts.

Table 10 -- Table of indirect costs

4.2.1. Gulfport indirect costs

Interviewees and documents in Gulfport mentioned 18 distinct impacts (for a total of 49 total mentions) that we classified as "indirect costs."

Lost business for ports and port tenants was mentioned 15 times in the documents reviewed and 7 times in interviews. The interviews mentioned that many businesses in Gulfport suffered or even failed due to Katrina and that five years after Katrina, the Port of Gulfport still operated at about 80% of its pre-Katrina business. Two major clients had shut down their operations at the port and at least one was still operating, out of a temporary facility on the grounds of the port. After Katrina, ports that were less damaged and less vulnerable were appealing to shippers that had been long established in Gulfport. As one official put it:

> *You can rest assured these other ports were running around trying to get our business. They knew we were suffering; and I can promise you they were knocking*

> *on each one of these guys' doors down here trying to get them to come to their ports. It's just the nature of the business.*

Delays in port-related commerce and increased prices were discussed by several interviewees, but were mentioned only twice in the port's planning and operations documents. Business interruptions occur in many sectors after a storm, but the port firms play an especially important role in the process of rebuilding communities: Since rebuilding and restoring a sense of normalcy depend heavily on the movement of materials, the lost business in and around the port can result in shortages of necessary supplies.

In reviewing the port planning and operations documents, we found no calculations and little explicit quantification of these indirect impacts even when the impact itself was mentioned. One exception was in the Mississippi Development Authority (MDA) report which cited a loss of "about 1,200 port-related jobs (direct, indirect, and induced)" over the two years following Hurricane Katrina (MDA 2011). We were not able to ascertain the methodology used to develop these job-loss numbers. MDA also reported port revenue falling significantly from about $20m/year in the years preceding Katrina (combined maritime and non-maritime) to about $9m/year in the two years following. These indirect costs fall upon the internal port stakeholders and many others within the stakeholder cluster. Indeed, determining who exactly will pay for these is difficult to ascertain. Interviewees also mentioned one *positive-spillover effect*: rebuilding can stimulate the economy.

Impacts such as *lost business for port and port tenants* can affect all stakeholders of the cluster: e.g., internal stakeholders lose lease revenues, economic/contractual stakeholders lose profit, the public loses the services provided by the individual businesses and potential jobs that are associated with those businesses. *Delays in port-related commerce and increased profits* affect

stakeholders in a similar way. Either the state or the economic/contractual stakeholders, along with the port operator, would often pay many of the costs associated with cleanup. The one *positive-spillover* impact noted by interviewees could benefit a number of stakeholders. Since cleanup and rebuilding stimulates the economy, the port, the economic/contractual stakeholders, and the public sector all stand to gain in some ways from a disaster, as well. For example, new jobs can be created in the construction sector and federal funding (e.g., FEMA and HUD grants) can benefit local workers and businesses.

4.2.2. Providence indirect costs

In Providence, we identified seven distinct types of indirect costs, including one positive spillover. All seven were mentioned in interviews, but only one *General business continuity problems* was mentioned in the documents we reviewed. Other indirect costs included *cleanup, emergency response, and emergency services costs* associated with cleanup and re-opening the navigation channel, as well as costs associated with *delays in port-related commerce*, such as business losses that would result from port businesses being shut down after the storm.

Unlike the direct damages, which would most likely be paid by the internal port stakeholders, external stakeholders would likely pay for many of the indirect costs. The result of a shutdown of the port or an important navigational channel for example (e.g., *cleanup costs* or *costs to survey the channel*), might be paid for through tax revenues or business losses experienced by port tenants and other external contractors. *Cleanup and emergency service costs* would likely be covered by the public agencies such as the Federal Emergency Management Agency (FEMA), the Rhode Island Emergency Management Agency (RIEMA), or the City of Providence. The State would also need to hire emergency relief workers, a cost not currently included in its

budget, according to one state representative.

4.3. Intangible Consequences

Intangible consequences is the broadest category. It captures a wide range of impacts, many of which occur in the months and years following the event itself. Many of these are many non-market consequences, which are very difficult to monetize, as there are often no economic measures available for evaluation. Table 11 shows the intangible consequences found in the two case studies.

Table 11 -- Table of intangible consequences

4.3.1. Gulfport intangible consequences

In Gulfport, we found 46 unique intangible consequences in interviews and documents combined. Many of the stakeholders focused on the many consequences of the debris resulting from Hurricane Katrina, including: the stench, the health hazards, and the difficulty of cleanup. For weeks after the storm, neither the MSPA, nor the tenants or the City addressed this problem. This debris resulted in many secondary impacts that were very difficult to monetize, yet were significant to the community. One interviewee, for example, indicated that salmonella from the rotting carcasses had made its way into the soil on homeowner's properties. In addition to the items that washed up on private property, debris ended up in the waterway, causing both environmental and navigation issues. As stated in one interview: *The water comes up, it moves into the coastal areas, and then when it's retreating back to the ocean it's pulling [all kinds of materials back], so going back [later] to do dredging work, you've got these [residual] issues from debris*.

Debris is especially problematic because of the difficulty in assigning responsibility for damages and cleanup. For example, if a shipping container floats free and causes a breach in a petroleum tank, which organization bears responsibility? The owner or insurer of the container? The longshoreman who secured the containers? The owner of the petroleum tank? According to the interviewees, the organizations in Gulfport litigated for years over these kinds of issues. After Katrina, there were more than 50 claims of this nature. As one respondent described it: *People [were] real pissed off about chickens being in their yard. It was crazy to blame and sue the port because they weren't even their chickens; they belonged to the shipping company.*

Interviewees described many other impacts that would be very difficult to quantify in economic terms. In the aftermath of Katrina, the costs of insurance policies rose, certain risks became uninsurable, and moratoriums were placed on new policies. Though aspects of these impacts may be quantifiable, many are not. For example, it is difficult to say how the inability to insure against future risk affects a business: Would the business operate anyway if authorized by its financial backers? Would it change its operations in some way? Would it move its operations? As one Gulfport respondent said, *[Without insurance], the whole economy was going to come to a frigging halt. Because if you can't insure it you can't finance it, if you can't finance it you can't build it*.

Another intangible consequence results from the *loss of use of the port due to damage*. An undamaged port can be an important resource for disaster recovery and response (Mileski and Honeycutt 2013). It can serve as a staging ground for supplies, manpower, and equipment. While not always defined as a "critical facility", like a hospital or fire station, a port can be instrumental in cleanup, recovery, and rebuilding. With roads and bridges closed, ports offer an alternative for bringing in goods and relief workers. However, a port that is severely damaged will not be

available to provide these services, as was the case in Gulfport after Katrina. One respondent described how even after the channel was cleared, the port was not able to support disaster relief ships because it had no water or sewer infrastructure.

After Katrina, a lack of available staff further hindered recovery resulting in another intangible consequence: *When people are trying to figure out their livelihoods and where they're going to live and everything, it's kind of hard to have them working for you.* These types of labor and employment consequences impacted many individuals and businesses in the region. Some of the port's employees had no homes and prioritized finding a place for their families to live over returning to work. Port officials also discussed how storms like Katrina could create additional *difficulties in port planning and development*. Plans for growing the Port of Gulfport that had taken years to develop had to be shelved and priorities reviewed after Katrina destroyed the port, setting the port's expansion timeline back by a considerable amount of time.

Respondents also talked about many issues that we categorized as *general disruptions to a sense of normalcy and the quality of life.* Some of these, like *disruptions of energy supply*, can be traced back to port uses (e.g., a damaged fuel terminal results in interruptions of fuel supply). Interviewees indicated that normal life was disrupted for months or even years after Katrina as residents worked to clean up and rebuild their homes and places of employment. Many respondents also talked about environmental consequences such as household chemicals and other materials that would end up in the waterway and marine sediment layer. Chemical contamination harms marine life and results in higher costs for dredging, as special techniques must be used to minimize contamination of the waterway and to dispose of toxic dredge spoils. In this way, even waterway contamination that occurred from an off-port location would still have an impact on port operations and costs since dredging is a requirement for ongoing

operation of the port. As one respondent noted:

> *Ensuring that the sediments are suitable for ocean disposal, upland disposal, or open water disposal becomes very costly as you may have [tested the sediment and] initially started to dredge, [but then] if you have a storm you may have to go right back and test it again, which could cost another $300,000 to $400,000.*

Consequence for the local and regional economy from losing port functionality included a variety of public sector concerns, as well as reductions in energy product imports and damages to other infrastructure commonly found at or near the port. For example, respondents talked about their experience trying to rebuild in a crippled local economy:

> *Immediately after Katrina, the infrastructure was not in place anymore to house and feed workers and handle all the rebuilding … materials were scarce, because everybody was fighting for a limited amount of building materials and products. Salaries went way up because there was a limited work force … everybody was in a bidding war for labor.*

Public sector impacts such as fuel availability for generators and transportation, lack of boat access to the navigational channel, and the costs of unemployment, all slowed down the recovery process. Some aspects of these intangible consequences may be quantifiable. For example, *lost jobs* in the labor and *employment consequences* subcategory may manifest as unemployment insurance costs. *Pollution to bay or waterway* may also be quantified using specialized techniques such as those used to value ecosystem services (Daily et al. 2009).

Generally speaking, the costs of intangible consequences that were identified through interviews and documents were distributed across the stakeholder cluster. The internal port stakeholders feel the effect of most of these, but most also can be felt in the budgets of public agencies and in, for example, the quality of life of community members in the local region and the state.

4.3.2. Providence intangible consequences

The 24 intangible consequences found in Providence ranged from *job losses*, to *disruptions in energy and critical service supplies*, to a whole host of potential *environmental damages* resulting from spills originating at the port. Some aspects of these impacts may be quantifiable in monetary terms (e.g., *port facility closures* do have a financial component, as well as other non-financial components), but many would be extremely difficult or even impossible to quantify in financial terms. For example, the *environmental damages* resulting from coal, cement, or other materials spilling into the waterway could have far-reaching implications for the whole ecosystem of the Narragansett Bay. One respondent described these consequences, as follows:

> *You have liquid petroleum products, cement, [and] a chemical company all of which are going to be submerged [and] subject to debris damage ... They're all going to be pulled right back into the Narragansett Bay, you're going to have a lot of potential impacts to a lot of important resources that are really hard to [comprehend]*.

Another respondent mentioned the intangible consequence *of losing the port as a resource in disaster recovery and response scenarios*, since ports can serve as staging areas for response efforts that aid in recovery. As discussed in the Gulfport section above, a severely damaged port could result in a longer and more difficult recovery process period, affecting the region as a whole (Spaulding et al. 2007; Mileski and Honeycutt 2013).

Six respondents also discussed impacts that fell into the broad category *of general disruptions to a sense of normalcy and the quality of life*. Since the port provides essential services to the region, losing port functionality results in *disruptions of energy supplies* and other materials that can negatively impact overall quality of life (e.g., residents have no fuel for heating or driving) and result in psychological stress (e.g., the shear scale of the disaster is overwhelming and leaves

residents with a feeling of hopelessness). A very real example of this occurred after Hurricane Sandy in New York/New Jersey when the damaged port infrastructure prevented necessary petroleum products from getting to the New Jersey refineries. Queues at the gas pumps stretched for miles and hours.

Debris was also cited numerous times, with some respondents describing debris that originated at the port and impacted other parts of the Bay. Other respondents discussed the impact that debris from elsewhere could have on port operations (e.g., debris could shut down the navigation channel as discussed in the Indirect Costs section above). The numerous mentions of debris were likely due in large part to a detailed study conducted by students at the University of Rhode Island (Spaulding et al. 2007). Five of the respondents indicated that they had read this study. We did not include the student report itself in our review of official planning and policy documents, since it did not qualify as an official planning or policy document of any of the stakeholders within the cluster. However, the "Hazards Chapter" of the Metro Bay Region Special Area Management Plan referenced many of the specific debris concerns brought to light in the student's report. In fact, of the 12 impacts we found mentioned in the Hazards Chapter, eight referred specifically to debris.

All of the stakeholders in the port cluster would share to some extent in the costs associated with these intangible impacts, though most of the costs burden would fall primarily upon external stakeholders. For example*, damage at the port prevents more efficient disaster response for region*, results from not having the port available as a resource for recovery: A functioning port could serve as a landing area for barges that collect debris; U.S. Coast Guard vessels performing survey work; a terminal for necessary fuel products,; among many other necessary functions. A damaged port also could result in individual tenants within the port losing their insurance

coverage, thus the service that those businesses supply (e.g., fuel supply, building materials, scrap metal or debris export) would also be unavailable as resources to the overall cleanup effort.

The *environmental damages*, such as chemical spills or bulk materials washing into the waterway, also result in costs that are difficult to quantify in monetary terms, but will ultimately be borne by society as a whole. For example, pollution could make the bay unsuitable for swimming or fishing and harm the sensitive marine environment that provides breeding areas for many species that make up the marine ecosystem. The quality of life of residents in the City and State could be affected by this type of pollution or other impacts, due to lost jobs, lack of access to gasoline or heating oil, or simply due to the psychological effects resulting from a disaster that destroys the port.

5. Discussion

The preceding sections described the results from interviews and documents in both Gulfport and Providence. Findings from each of the three broad categories of impacts were discussed, with examples provided from each of the two case study locations. These results provide empirical evidence for the vast range of impacts that can occur when a major hurricane hits a port, as well as an assessment of which stakeholder groups would likely bear the costs (financial or otherwise) for these different types of impacts. The next sections put these results into context. In Section 5.1, the three original research questions are discussed, with detail from each of the two case studies locations provided in turn. We then provide some comparative analysis between these two case studies in Section 5.2, with a focus on the similarities and differences and where results might be more generalizable to other ports. In Section 5.3, we discuss some of the planning and policy implications from these findings, with a particular focus on leadership issues, the use of

qualitative assessments for policy, and some of the unique challenges of seaport resilience planning. Finally, we address the limitations and next steps for this work.

5.1. Summary of research questions findings

In this section, we address the three research questions posed at the beginning of this paper for each of the two case studies.

5.1.1. QUESTION 1: How do port stakeholders in Gulfport (MS) and Providence (RI) perceive the impacts of a major hurricane hitting the port

This question was designed to ascertain how different stakeholders think about a major hurricane hitting the port. We did not set out to assess level of concern or priorities, rather we wanted to provide a catalogue of impacts that could be further tested and assessed in future work. We also analyzed how the different groups of stakeholders considered the impact types by averaging the total number of impacts mentioned by respondents from each group. These results are depicted in the radar plots in Figure 14 and Figure 15. We first discuss perceptions of stakeholders in Gulfport and then Providence.

Perceptions of Stakeholders in Gulfport

Stakeholders interviewed from the Port of Gulfport consisted primarily of public agencies at local, state, and federal levels (16 total), but also included economic/contractual firms in and around the port itself (3). There were five port officials interviewed and one community group. In sum, stakeholders mentioned more unique intangible consequences (28 total) than direct damages (16 total) or indirect costs (13 total) Figure 14 shows the average number of impacts

mentioned by interviewees from each of these five major parts of the port stakeholder cluster. For example, on average internal port stakeholders (of which five were interviewed) mentioned 4.5 direct damages, 2.6 indirect impacts, and 3 intangible consequences each. This suggests that these stakeholders, as a group, were fairly well balanced in how they considered the impacts across the three broad categories. The other stakeholder groups all skewed toward more mentions of intangible consequences, as opposed to direct damages or indirect costs. In interviews, port officials showed a deep understanding of the variety of impacts, as well as the ripple effects that these impacts can have. In fact, they had been dealing with the aftermath of Hurricane Katrina for several years and working toward building a more storm resilient port. They discussed many of the direct damages from Katrina, as well as the impacts on the economy and the surrounding community. As we will see in Section 5.1.3, many of these concerns were not reflected explicitly in the port's plans and policies, but the representatives themselves had a very high level of awareness around the various impacts of a storm like Katrina or the one depicted in the scenario we provided.

Figure 14 -- Impacts by stakeholder group (Gulfport)

As an aside, climate change will increase the probability of storms like Katrina in the coming decades (Grinsted et al. 2013). Though we did not set out to interview stakeholders about climate change specifically, many of them discussed climate change as they were answering questions about how they perceive the impacts of potential storms. Respondents were fairly evenly split between those who were and were not concerned about climate change impacts. One concerned respondent stated:

[We] lack a look at sea level rise in the region. Not just for the Port of Gulfport,

> *but for Harrison County. What is sea level rise going to do to the total infrastructure of Harrison County? Well it's going to totally destroy it…Raising the port to 25' elevation is stupid, because the surrounding land is not at 25', and they're not going to raise all of Harrison County. So yeah, your containers will sit there, but everything in them is going to rot because you're not going to be able to get them off the port … The way the area's developed, you'd have to totally destroy downtown Gulfport [in order to make the port] truly resistant to sea level rise.*

As one unconcerned respondent put it, *I hadn't really thought about it; I mean I'd thought about global warming and how it raises the water, [but I thought] it was insignificant. The contractor told us that it didn't really matter*. Others were under the impression that sea level rise had already been taken into account in the elevation plan: *Flooding . . . is one of our concerns … I'm pretty sure [the port considered] sea level rise.* The new floodplain maps drafted by FEMA do not, however, incorporate any climate change projections (FEMA 2009).

Perceptions of Stakeholders in Providence

The Providence stakeholder cluster interviewed consisted of three internal port representatives, 16 from the public policy sector, seven from economic/contractual firms, three from academia, and one from a community/environmental group. Interviews mentioned 14 unique direct damages, seven indirect damages, and 15 intangible consequences. As above, we assessed how different stakeholder groups considered impacts of our storm scenario by simply averaging the number of unique impacts mentioned for interviewees in each stakeholder group. Figure 15 shows a radar plat with these results and suggests that different types of stakeholder think about impacts in different ways. The port representatives focused more on the direct damages and indirect costs, with no mentions at all of the intangible consequences of the event. Both public agencies and academics tended to talk about the intangibles more and the economic/contractual stakeholders talked about all three types. Though the sample size was small, these findings do

suggest that gaps may exist in how different stakeholders consider these types of storm impacts.

Figure 15 -- Impacts by stakeholder group (Providence)

5.1.2. QUESTION 2: How will internal and external stakeholders bear the costs resulting from a hurricane hitting the port?

This question was designed to explore how the costs of the impacts identified might distribute amongst different stakeholders. Port stakeholders of Gulfport (MS) and Providence (RI) identified a wide range of direct damages, indirect costs, and intangible consequences of a hurricane hitting the port and these would result in costs that would be borne by all port stakeholders as well as society as a whole, as depicted in the tables in Section 4. For each of the impacts noted, we assigned the cost (economic or non) to one or more stakeholders, based on our own intuition as informed through interviews and a review of organizational missions and mandates. Overall, we found that these costs were well distributed throughout the stakeholder clusters, with the port bearing the most responsibility for *direct damages*. The *indirect costs* and costs associated with *intangible consequences* will likely fall more heavily upon the external stakeholders, as seen in rather than on the internal stakeholders of the port. All stakeholders will bear the costs to some extent, with the potential impacts affecting the environment, quality of life, jobs, emergency recovery, and much more. Next we look at costs for each of the case studies independently.

Costs in Gulfport

Figure 16 shows what percentage of the distinct identified costs fall upon each of four

stakeholder groups.[3] The internal port (i.e., the Mississippi State Port Authority at Gulfport) and the economic/contractual stakeholders (e.g., the shippers, insurance companies, and port tenants) would likely bear a large percentage of the direct damages (93% and 83% respectively) and the indirect costs (94% and 83% respectively). Eighty percent of intangible costs would be borne by the public policy (and by implication, taxpayers) and community/environmental groups. Though this analysis does not indicate the magnitude of costs, it does suggest that the external stakeholder groups will likely be most affected by the indirect costs and intangible consequences resulting from a hurricane hitting the port.

Figure 16 -- Costs upon stakeholders (Gulfport)

Costs in Providence

In Providence, the costs distributed similarly to Gulfport: the internal port and economic/contractual stakeholders would bear the highest percentage of the direct damage and indirect costs, while the public policy and community/stakeholder groups would bear the highest percentage of the intangible costs (Figure 17). However, differentiating between the external and internal stakeholders is fuzzier in the case of Providence, in particular when assessing the costs of the various impacts identified. Unlike Gulfport, where the port is contained in one very specific location and operated by the MSPA, the Port of Providence covers a large geographic area and includes numerous independent firms. There is no overarching port authority with responsibility for the entire district. For the purposes of this analysis, we assigned costs to the Port (i.e., Waterson Terminal Services) only if the Port itself would directly pay for the repair or recovery cost.

[3] In this portion of the analysis, the "academic/research" stakeholders are excluded, as these stakeholders would not likely bear any unique to them as a stakeholder group.

Figure 17 -- Costs upon stakeholders (Providence)

No impact assessments had been conducted in either Providence or Gulfport with a goal to identify the full range of impacts at a scale that is wide enough to capture concerns of multiple stakeholders of the port, yet narrow enough to trace the root of the impact back to one particular facility. Results from these case studies suggest that much of the burden for these external costs, as well as those internal costs that exceed the port's insurance coverage will ultimately be borne by the public in the form of disaster relief, cleanup and rebuilding costs, and negative impacts on the environment and quality of life. These case studies identified an area for future research into disconnects between current port resilience planning practices, impacts assessments, and understanding the costs of storm impacts at ports that are ultimately borne by the public.

5.1.3. QUESTION 3: In what ways are port stakeholders considering the resilience of the port in planning and policy?

In this section, we compare the impacts that were identified in existing planning and policy documents with those concerns expressed in interviews. To appropriately plan for port resilience, the full range of impacts and cost burdens must be understood and accounted for through port planning, local/state planning, or both. These impacts may be identified through vulnerability assessments (Bierbaum et al. 2013; Preston et al. 2010) or incorporated into other more general plans. Through the review of documents for these two case studies, we found that Gulfport had 16 planning/policy documents that assessed Hurricane Katrina damages in the region and at the port, but we found no study that could be considered a "vulnerability assessment" that addressed the port specifically. Providence had six planning/policy documents that addressed both the port and storms and two that could be considered vulnerability assessments, though not vulnerability

assessments of the port specifically. In both cases, far more impacts were discussed in interviews than in documents and intangible consequences figured prominently in the minds of interviewees. We next examine findings from each of the two case studies.

Gulfport's documents vs. interviews

Interviews and document comparison shows the differences between how stakeholders perceive impacts of the storm and how the port's planning documents address them. Figure 18 shows the number of mentions for each of the three categories of impacts in interviews only, documents only, and both interviews and documents. Overall, the specific impacts of past or future hurricanes at the port received little attention in the documents. The port's own planning and policy documents from Gulfport focus primarily on direct damages, with very few mentions of intangible consequences. Most of the specific impacts that were noted in these documents, originated from just one source: the damage assessment conducted by the MSPA after Katrina. This report went into great detail on the individual direct damages to port property.

Very few indirect costs were cited in the documents, but those that were, included tonnage declines, employment losses, and lost tenants. Missing from the documents was analysis of the role the port plays in the wider region and the many ways that damage to port infrastructure ripples out to affect the port cluster as a whole. Interviewees, on the other hand, were far more concerned with the intangible consequences. This suggests that stakeholders of the port cluster had many concerns about hurricanes at the port that had not been formally addressed through planning and policy resulting in found a gap between stakeholder concerns and resilience planning for the port

Figure 18 -- Impacts mentioned in interviews vs. documents (Gulfport)

Of the documents analyzed and coded from Gulfport, ten were drafted by the MSPA and addressed plans to restore and expand the port after Katrina. This project was funded through The Federal Department of Housing and Urban Development (HUD) through a $621m grant from the Community Development Block Grant Disaster Recovery Program to rebuild and repair the damage caused by Hurricane Katrina (Becker 2013). The allocated funds were to "provide mitigation against future damage, prevent future recurrence of damage and destruction in Hurricane events, and provide the long-term recovery of the operating capacity of the Port (MSPA 2010)," though no specific requirements were attached to the funding. Then-Governor Haley Barber also prioritized a port that would be more storm resistant. In the plan, the improvements would potentially attract new customers, as no other port on the Gulf Coast offers such hurricane protection.

Public comment and review for the elevation project reflected that the broader stakeholder cluster did not bring these concerns to the attention of the port. Most of the public comments addressed job creation, instead of the hurricane protection strategies the port planned to incorporate. For its part, the MSPA's main mission is to be "a profitable, self-sufficient port providing world-class maritime terminal services to present and future customers and to facilitate the economic growth of Mississippi through the promotion of international trade and creation of employment" (CH2M Hill 2010). There is no explicit mandate for the port to consider the interests of other stakeholders in the cluster or the long-term viability of the port, though many interests and goals are common to both groups. In addition, the funding the port received for the project had no specific requirements for hurricane resilience; rather, the HUD mandate was tied to job creation. By the time our research was completed, the port commissioners had voted to abandon the elevation plan entirely in favor of investment in a channel-deepening project. As

stated by one of the port commissioners in a newspaper article, "I need to move forward. We need to get jobs. We need to get moving out and get this behind us" (MSPG 2012). A logical next step would be surveying the stakeholders themselves to better quantify their perceptions of the importance of the various impacts noted by the cluster as a whole.

Providence's documents vs. interviews

Given the far-reaching impacts across the stakeholder cluster, one might expect to find port resilience against hurricanes referenced in many of the Providence documents we reviewed. However, most of the stakeholders in the cluster had no planning or policy documents that specifically addressed port resilience and those that did address it, did so in a cursory manner. Sixteen impacts total were mentioned in the six documents, fewer than half the number discussed in interviews (Figure 19). About half of the impacts identified in these documents came from just one plan: the "Hazards Chapter" (CRMC 2011) of the Metro Bay Special Area Management Plan (SAMP). It mentions seven specific impacts, with eight references to debris. It also mentions three of the direct damages that could occur at the port itself and it includes the port in its list of critical facilities. Other plans, however, did not include the port as a critical facility. In the Hazard Mitigation Plans, for example, *critical facilities* were specifically discussed in terms of their vulnerability, but the port was not addressed. These are defined as those "that are critical to the health and welfare of the population and that are especially important following disasters." The plan goes on to identify *nine* specific types of critical facilities: marinas, shelters, schools, hospitals, fire and rescue stations, police stations, water supply points, and rail road stations/airports. The port does not show up in this list, nor is it mentioned explicitly as a potential resource following a disaster, despite research that indicates role a port can play in post-disaster recovery (Mileski and Honeycutt 2013). Similarly, the plan provides specific analysis for

"state owned/operated facilities," but because the port is not state owned or operated, it received no explicit mention as warranting special consideration.

Figure 19 -- Impacts mentioned in interviews vs. documents (Providence)

The City of Providence Hazard Identification and Risk Assessment (PEMA 2010) also addressed port issues, but the assessment focused primarily on terrorist attacks with respect to the port. The plan only notes that flooding poses a threat to shipping, port operations, business and property and that, "Uninterrupted port operations have economic benefits to the City." It provides no further analysis, though does include a recommendation for the City of Providence to conduct further study of the port to, "Identify upgrades necessary to limit damage due to flooding and earthquake" and to "Retrofit the Port of Providence facility to protect against flood and earthquake damage."

The planning gap suggested in our findings is confirmed in part in a passage of the Hazards Chapter of Rhode Island's Coastal Resources Management Program (CRMC 2011), that states this as an area of concern:

> Existing [planning] documents (either outdated or in draft form) do not adequately address or link to other plans to address hazard issues on the waterfront. This is problematic because of the unique hazards present in the port districts of Providence ... The port areas … carry major infrastructure and supply the region with critical goods, in both post- and pre-hazard conditions. Guidance could include evacuation of shore-side facilities, structural mitigation of shoreline structures, safe harbor recommendations, and boat pullout procedures and priorities, as well as address other concern issues such as spills, contamination caused by inundation, and facility closures. It should be noted additionally that new requirements for facility evacuation, import of supplies, emergency transport, etc. might be placed on this infrastructure in the case of a hazard scenario.

Another aspect of the planning gap results from construction of existing infrastructure in the port

area being completed decades before appropriate land use and building codes took affect, as noted by the CRMC (2011). Much of that infrastructure still exists and is operational, despite designs that would not be up to today's regulatory standards. However, even structures build in recent decades in accordance with current codes and regulations are not designed to withstand new environmental conditions likely to occur due to climate change. The results of analysis of interviews and documents in this case study indicate that the concerns of stakeholders and the potential impacts of a hurricane hitting the Port of Providence have not been addressed in the stakeholders' formal planning documents.

5.2. Comparative assessment of Gulfport and Providence

This study was not designed to be a comparative cases study, as many variables differentiate these two ports (e.g., size, type of cargo, management structure, etc.). However, there are some overall observations that can be made between the two and they contribute to a deeper understanding of what happens to the port stakeholder cluster when the port suffers a major hurricane. In Providence, stakeholders identified many such potential impacts *ex ante* an actual storm event. We found many similarities and some marked differences between impacts noted in Providence and those noted *ex post facto* by stakeholders in Gulfport This section discusses first the similarities and then the differences between the two case studies.

5.2.1. Similarities between Gulfport and Providence

In both case study ports, planning and policy documents addressed few of the concerns expressed by stakeholders. This was the case both in Gulfport, where the Mississippi State Port Authority (MSPA) was focusing on implementing a resilience strategy in response to a recent hurricane, and Providence, where no such effort existed, but there was a culture of leadership

around climate adaptation in the State.

In Gulfport, post-storm impact assessments from Katrina addressed *direct damages* at the port and other impacts on a regional scale. These assessments provide information that can serve as a foundation for resilience plans, such as the one that was being undertaken for the Port of Gulfport. Though the MSPA had plans for a resilience strategy, the planning documents included little input from port stakeholders about storm impacts and few references to the many concerns identified in interviews. In Providence, no post-hurricane event impact assessments for the stakeholders had been conducted, due to the fact that no such event has taken place in their recent history. There were, however, vulnerability assessments conducted on statewide and citywide scales, but these did not specifically address the port or its stakeholders in detail. Although one university study done in Rhode Island identifies many of the consequences of a storm *ex ante* (in particular with respect to debris), most formal documentation either does not address the port directly or focuses primarily on emergency response. Neither interviews nor the documents in Providence identified any established process for identifying the wider impacts that a storm event would have on port stakeholders.

Though Gulfport results showed a higher number of impacts cited overall, the trends were the same in both case studies. In both, the highest number were *intangible consequences*, followed by *direct damages*, and then *indirect costs*. Providence and Gulfport respondents identified a comparable number of intangible consequences and in both cases debris stood out as a top concern. All three of the individual impacts that were cited with the highest frequency fell into this category. In Providence, the top impacts mentioned most frequently in interviews were *debris* (11 times), *pollution to the waterway* (11 times), and *disruption in energy supply* (10 times). The first two of these were each mentioned twice in the Providence planning documents.

In Gulfport, the top impacts mentioned most frequently were *containers all over the city* (20 times), *chicken and pork bellies all over the city* (13 times), and *debris polluting the environment* (nine times). Cleanup of debris in and around the Port of Gulfport took more than six months after Katrina, explaining why this was a top concern (Miller and Birdsall 2010).

Like in Providence, Gulfport stakeholders felt concern over a very wide range of potential impacts resulting from a lack of resilience at the port. Like Providence, no formalized process existed to ensure that these concerns were recognized and incorporated into the planning process. The consequences of a hurricane hitting the port and the costs these events have for society as a whole suggest that bridging this planning gap would benefit all stakeholders.

5.2.2. Differences Between Gulfport and Providence

While Providence interviewees tended toward more generality in their descriptions of potential impacts, Gulfport interviewees were more specific as they had prior and direct experience dealing with a hurricane at port. This resulted in a far greater number of total impacts mentioned in Gulfport than in Providence. Gulfport's respondents and document review yielded far more specifics in the categories of *direct damages* and *indirect costs*. For example Providence interviewees mentioned a general, *Damage to port equipment*, while Gulfport interviewees mentioned the specifics of, *Damage to cranes* and *Damage to the fencing system*. Gulfport's planning documents for port restoration also focused far more attention on *direct damages* than on the *indirect costs* or *intangibles consequences*. Given that Gulfport was still recovering from Hurricane Katrina at the time of the interviews, it is not surprising that they had a much higher awareness of some of these specific impacts.

Worth noting is how little overlap there was between the specific impacts identified in the two

case studies. Of the 107 distinct impacts mentioned, only 17 occurred in both case studies. Though both ports face high hurricane exposure and both are small to medium sized ports, like all ports, they are quite different in terms of cargo handled, environmental conditions, management, and equipment. This finding suggests that, while it is difficult to generalize with respect to the unique ways that hurricanes impact port stakeholders, the overall trend of concern for higher proportions *intangible consequences* may hold true across all ports, though this requires further testing.

Although the sample size for both Providence and Gulfport is small, we analyzed how internal stakeholders of the port considered impacts. Results in Section 5.1 suggest that the internal stakeholders of the Port of Gulfport have a much broader awareness of the full range of impacts than their counterparts in Providence This is likely because:

1. Port of Gulfport is operated by a state port authority and thus more engaged with other stakeholders, and
2. The experience with Katrina left the interviewees with a much more detailed understanding of what actually happens as a result of a major storm, suggesting that site visits between these two ports could be a way to share lessons learned.

The preceding section provided some analysis comparing the results from the two case studies. We next take a big picture view of the broader implications this work has for planning and policy.

5.3. Planning and Policy implications

This research was designed to contribute a better understanding of the nature of the climate change problem for one particular port stakeholder system in two case study ports. It does not allow for a detailed assessment of the many other factors, including: the magnitude of impacts,

how the impacts are linked, probability of the various impacts, their specific costs, how stakeholders prioritize their concerns, and many other issues that would be components of a thorough vulnerability assessment at the stakeholder scale. This exploratory study, rather, yields results that represent the diversity of consequences that stakeholders perceive to be of importance when a major storm hits a piece of infrastructure – in this case, the port. This case study lays the groundwork for future research on seaport resilience that can be conducted at a scale that is narrow enough to be able to trace impacts back to one source e.g., a port), but broad enough to recognize the role that the port plays for a wide variety of stakeholders. Two issues in particular, however, emerged as particularly relevant for planning and policy: a lack of leadership and a need for qualitative impact assessments for ports. These are discussed below in more detail.

5.3.1. Leadership issues

This analysis revealed a lack of clarity around leadership issues for building long-term port resilience in both ports. In Providence, no clear leadership responsibility for building the resilience of the port emerged, even though the perceptions of consequences of underscore the critical nature of resilience planning. In Gulfport, documents and interviews indicated that resilience planning was left primarily to the port, but that the port's planning process was driven predominantly by profit and job creation goals leaving some stakeholder concerns out of the planning process. Traditionally, port planning has taken place within the confines of the port operating business (often the port authority), with little input from other stakeholders.[4] The task of enhancing the port's resilience to a level that adequately protects all stakeholders, and thus the

[4] In Europe, for example, a survey conducted by the European Sea Ports Organization found that only 17% of ports involved local communities and stakeholders in port development plans (Brooke 1991).

public interest, is likely beyond the means of any given port operator. Though there are strategies that fall within the mandate, jurisdiction, and missions of all organizations, a coordination of individual efforts would be necessary. A master planning effort would be one way to ensure that the implementation of individual strategies complemented each other and that moving toward resilience could occur in a coordinated fashion.

The Port of Providence comprises a complex group of private and public entities. The port terminal itself, ProvPort, operated by a private company, does not have a strategic planning process that includes port resilience, nor does it have the financial or staff resources to invest in leading a climate adaptation effort that addresses storm resilience issues. The same holds for the many other smaller businesses that make up the Port of Providence. Since, overall, the Port of Providence provides a public good, the government is positioned to play a role in conducting vulnerability assessments, adaptation planning, and creating policy that leads to appropriate levels of resilience to protect the greater interests of society. However, much of the port falls outside of the jurisdictional authority of the state since it is located landward of the mean high tide line that delimits public and private property. Though some port lands are owned by the City of Providence, respondents indicated that the City stays mostly uninvolved in planning and operations.

Research and academic organizations, such as the Coastal Resources Center (CRC) at the University of Rhode Island, are poised to facilitate assessment and planning at a stakeholder scale. On behalf of the CRMC, the CRC has facilitated similar processes in the past that resulted in changes across stakeholder groups. For example, a "Balancing Uses of the Working Waterfront" workshop brought stakeholders together to assess ways that seemingly conflicting uses could be better harmonized (CRC 2007). This effort resulted in changes to state and city

policy, business plans of independent firms, and the formation of a new stakeholder alliance group that now represents the common interest of waterfront businesses. Because the CRC served as a neutral facilitator, diverse stakeholders came together to share information freely and plan for mutually beneficial outcomes. A similar effort could help focus research and planning at the port stakeholder scale for adaptation planning.

5.3.2. Qualitative impact assessments

In Providence and Gulfport, many concerns expressed by stakeholders were not identified in planning and policy documents, suggesting a disconnect between how stakeholders perceive impacts and how official policy addresses these impacts. Categorizing, quantifying, and assessing impacts of natural disasters on specific sectors are daunting but critical components of disaster-mitigation planning (Canton 2008). Results indicate that planning and policy should consider more than traditional quantitative direct damage assessment by including qualitative assessment tools that address indirect costs and intangible consequences resulting from a hurricane at the port. While reducing the risk of direct damages also reduces the risk of many of the other impacts, a broader range of considerations would be appropriate, especially given climate change. Concerted efforts to include the full range of stakeholders in planning/policy for resilience could help bridge the gap between concerns and how they are accounted for in these documents. Even in Gulfport where Hurricane Katrina devastated the port, the resilience portion of the port's strategic plan is largely overshadowed by the desire to expand operations, increase tonnage throughput and create jobs.

These case studies did not seek to monetize or otherwise quantify the actual costs of impacts. Rather, they served to help identify and define perceptions around the nature of the problem that

climate change presents to stakeholders of the port as storms intensify and sea levels rise. Many of the impacts do not appear to be considered in stakeholder plans and policies for enhancing port resilience. The impacts reported most by stakeholders (intangible consequences) are those that appear least in the formal planning documents and also those that are most conducive to qualitative assessment. This gap leads to many questions, such as: Are the investments in resilience enhancement adequate to meet the needs of the full cluster of stakeholders? If the direct damages were mitigated, which indirect costs and intangible consequences would also be mitigated? Given how few of the stakeholders' concerns are reflected in the port's planning documents, how comfortable are the stakeholders with the level of resilience the port is planning?

5.3.3. The issue of scale

Though we did not set out to address the question of "why" specifically these types of gaps may exist, analysis of interview data and documents suggest one potential reason: Planning gaps may result from both a mismatch of timescales and geographic scales, as port operators make investment decisions based primarily on the interest of the *port as a business*, while state and regional planning efforts do not address the port specifically enough to protect society's long-term interest in port functions. Port operators typically make investment decisions based on the best interest of port business on a 5-10 year time horizon, as found in a recent survey of port authorities perspectives on climate adaptation (Becker et al. 2012) and in descriptions of the strategic planning process for ports (Allen 2012; Dooms and Macharis 2003). Considering the impacts of strong hurricanes in the face of climate change, on the other hand, must include time horizons that are well beyond the 5-10 year range for the sake of both the business interests of the port and the interests of the other external stakeholders in the cluster.

In addition to the mismatched timescales, the geographic scales may be mismatched. For example, the port planning process tends to focus on the port business alone (very local scale), while the public policy planning process tends to be more regional in scale. The "stakeholder cluster" scale is between the two. This was evident in Gulfport where damage assessments were either regional or port-specific, but did not focus at the stakeholder cluster scale to examine the ways that damage to this one piece of infrastructure affected its many stakeholders. In Providence, there were regional assessments, but also none that addressed either the port cluster or the port specifically.

5.4. Limitations and next steps

There are numerous next steps involved in effective planning for a future that includes more frequent and more intense storm events. One next step would be conducting a more formal risk analysis that allows for probabilities and specific costs to be assigned to the various impacts and asks stakeholders to prioritize and their level of concern. There are numerous tools that can aid in this decision support process (Haymaker and Chachere 2006) and similar exercises have begun to be carried out, though not at the port stakeholder-cluster scale described here (see for example the Port of San Diego 2013).

The case studies, too, had several limitations. First, the sample size was relatively small, making it difficult to compare how different sectors of stakeholders felt concern about different types of impacts or how different types of stakeholders perceived strategies differently. Results did not assess how stakeholders prioritize the various impacts or strategies they mentioned. Just because an impact was mentioned twice, for example, does not necessarily mean that it is of greater importance than an impact only mentioned once. It would also be valuable to consider the

linkages between impacts, as reducing the vulnerability for one *direct damage* might offset multiple *indirect costs* and *intangible consequences*. Interview analysis also indicates some perception gaps in how different types of stakeholders consider impacts. For example, little concern was expressed for impacts on the environment or on the intermodal system with which a port interfaces. An assessment of how these gaps in perceptions align with jurisdictions and mandates would help ensure that all aspects of impacts are considered in future resilience plans. The impacts collected in this research were also generated from within the stakeholder cluster itself. There are likely additional impacts that were overlooked, but are nevertheless significant. Finally, the interviews did not specifically emphasize questions of strategy implementation, because, even though stakeholders identified potential strategies, they did not discuss who would/should take a leadership role, how effective the strategies would likely be, the suitable timeline for their implementation, and how they would be funded. These questions can be addressed through further work in these and other case study locations.

Had interviewees been more specific, some of the intangible consequences may have been categorized as *indirect costs*. However, the interviewees tended to talk about impacts in very broad terms; thus it was difficult to determine which, if any, aspect of the impact could be quantified in financial terms. In many cases, coding their concerns with specificity was extremely difficult. For example, many interviewees made statements like, *You're going to have a lot of potential impacts to a lot of important resources that are really hard to [comprehend]*. In some cases, follow up questions elicited more specificity, but many interviewees were vague when it came to details. This challenge, however, only underscores the necessity for the type of research undertaken in this case study so that potential impacts can be named, perceptions shared, and ultimately better planning and policy developed to address them.

Assessing how stakeholders prioritize the various impacts was not covered in this study. Just because an impact was mentioned twice, for example, does not necessarily mean that it is of greater importance than an impact only mentioned once. It would also be valuable to consider the linkages between impacts, as mitigating one *direct damage* might offset multiple *indirect costs* and *intangible consequences*. A next step is to revisit the Port of Gulfport and ask stakeholders to prioritize and rank the relative value of the different impacts mentioned, as well as to trace the pathways between impacts. A network analysis tool could help determine which impacts stand out as central nodes from which other impacts result.

Our interview analysis indicates some perception gaps in how different sectors of stakeholders consider impacts. For example, little concern was expressed for impacts on the environment or on the intermodal system with which ports interface. An assessment of how these gaps in perception align with jurisdictions and mandates would help identify areas that warrant more attention in planning. If, for example, federal entities show concern for environmental impacts but have no mandate or jurisdiction over the potential source of those impacts, then improved communications and planning could help address this disconnect.

The impacts noted in this study are limited to the perceptions of those identified by the stakeholders within the port cluster itself. There may be other impacts that were either unknown or not identified by these stakeholders. An "expert analysis" by a group external to the stakeholder cluster could identify these other potential impacts.

6. Conclusion

These two case studies utilized a grounded theory approach (to create impact names and

subcategories) combined with a deductive analysis approach (to determine broad categories in accordance with IPCC definitions) to create a categorization of impacts and an analysis of which stakeholders would likely bear the cost for each. Through a review of official documents and interviews with port stakeholders, we found that stakeholders perceived a wide variety of impacts and costs resulting from a hurricane hitting the port and that these impacts fell into the three broad categories defined by the IPCC (IPCC 2012). These include *direct damages* to the port (including the waterway and intermodal connections), *indirect costs* that can be quantified in economic terms and *intangible consequences* that cannot be easily quantified in economic terms.

Interviews and planning/policy documents from Gulfport show that stakeholders perceive that storms at the port result in direct damage to the port itself, but also on the quality of life and business in the region, and the environment. Stakeholders described their experience with Hurricane Katrina and their concerns for another similar storm. Gulfport makes for an excellent case study because of its experience related to hurricane Katrina and the MSPA's consideration of plans to rebuild in a more hurricane-resistant fashion. Many stakeholders' concerns did not appear in formalized documents that concerned planning and policy for the port. We also found that hurricane resilience was not a priority for respondents when it came to providing commentary and input to the port's planning process. In the face of climate change, we suggest that port resilience plans consider not just the impacts on the port itself, but the impacts storms have on the wider port cluster. As seen in this study, the true costs of an event at the port are distributed amongst many stakeholders. The concerns expressed by stakeholders and the port's decisions about resilience strategies suggest that stronger stakeholder engagement would help future resilience planning efforts.

In Providence, the results from this study suggest that while a collective awareness around

hurricane impacts on port stakeholders exists amongst stakeholders, the port planning and policy documents include little guidance on port resilience generally, and explicitly mentioned only about half of all identified impacts. Neither the port operator, nor the external stakeholders of the port, addressed long-term resilience planning in their policies and plans in any detail, yet external stakeholders outside of the port are at risk for shouldering many costs associated with a lack of proper planning.

Both cases show an overall trend of high levels of concern for *intangible consequences* and many costs that will be borne across the stakeholder cluster. Both also show gaps in how impacts are addressed through official planning and policy. These findings suggest that the diversity of impacts resulting from a hurricane hitting these ports, the increasing risk of these events due to climate change, and the potential costs to society, warrant that planners and practitioners more fully consider port resilience and hurricane impacts in future planning efforts and bridge the gap between perceptions and formalize planning/policy. We suggest that understanding how stakeholders, planners, and policy makers as a cluster perceive these impacts can lead to a greater emphasis on resilience planning for the port that benefits all stakeholders.

END

7. References

(see attached)

FIGURES

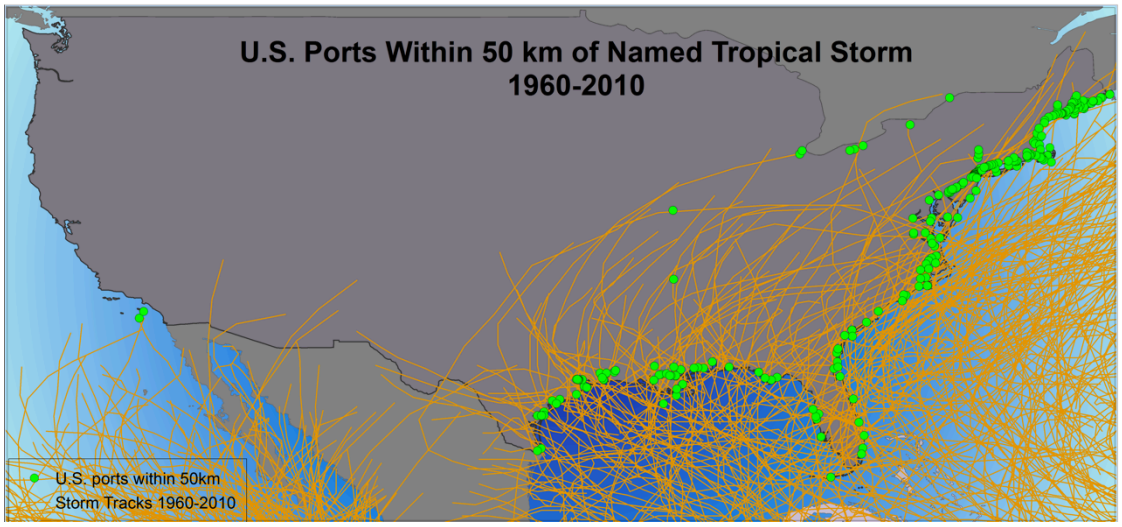

Figure 1 -- Map of U.S. ports within 50km of named storm
(Port and storm data from National Geospatial Intelligence Agency (NGIA 2011) and (Knapp et al. 2010))

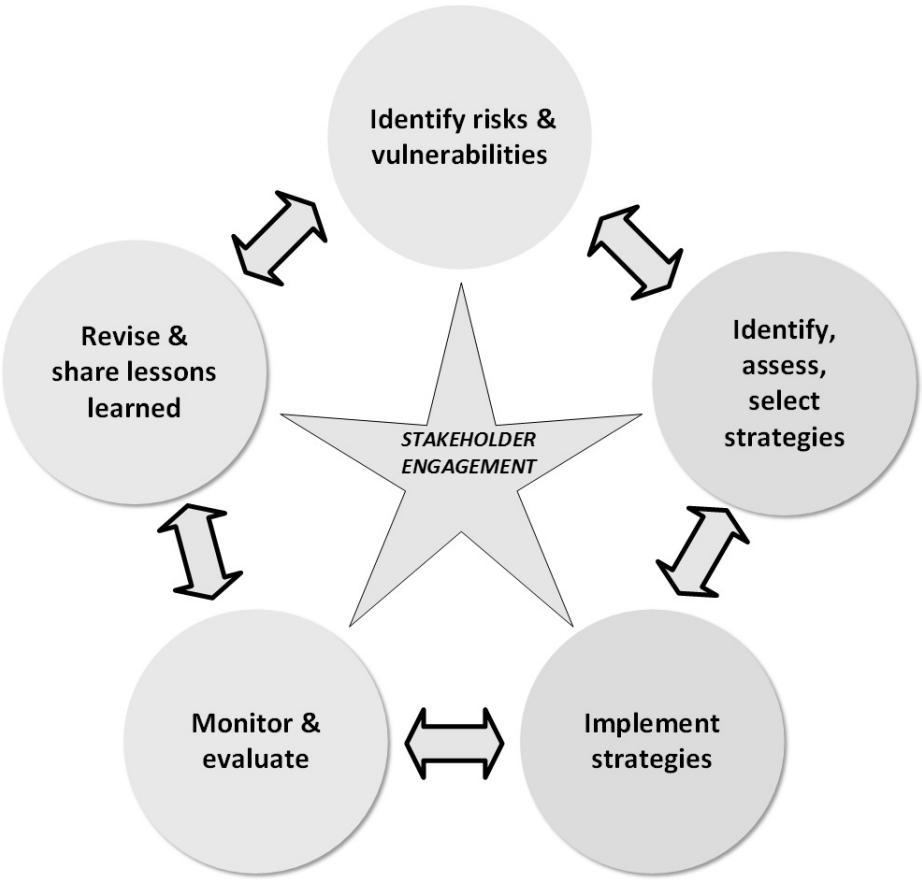

Figure 2 -- Climate adaptation process (NCADAC *Draft*)

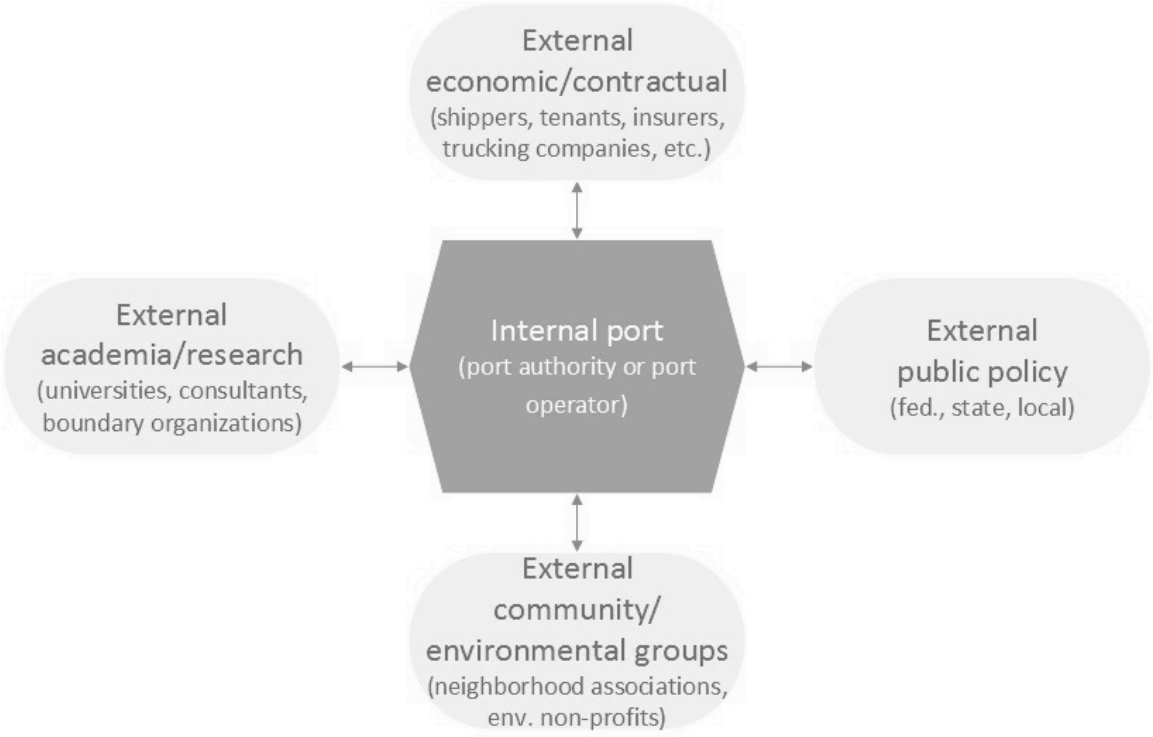

Figure 3 -- Stakeholder cluster (Based on Notteboom and Winkelman, 2002)

Figure 4 -- Map of Gulfport and Providence

Figure 5 -- Aerial view of Port of Gulfport (www.portofthefuture.com)

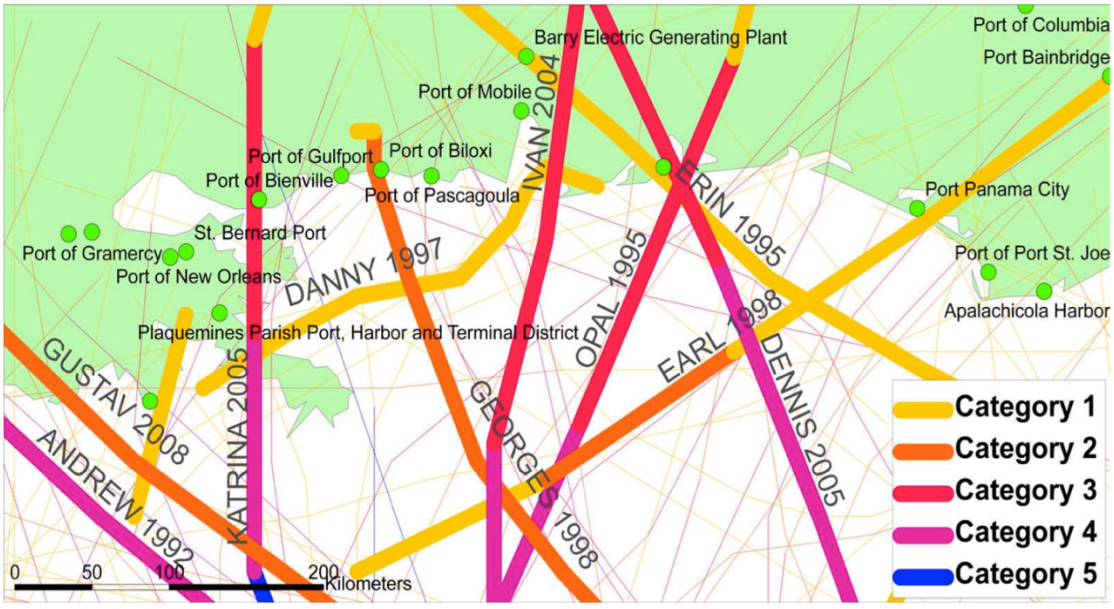

Figure 6 -- Hurricane tracks near Gulfport

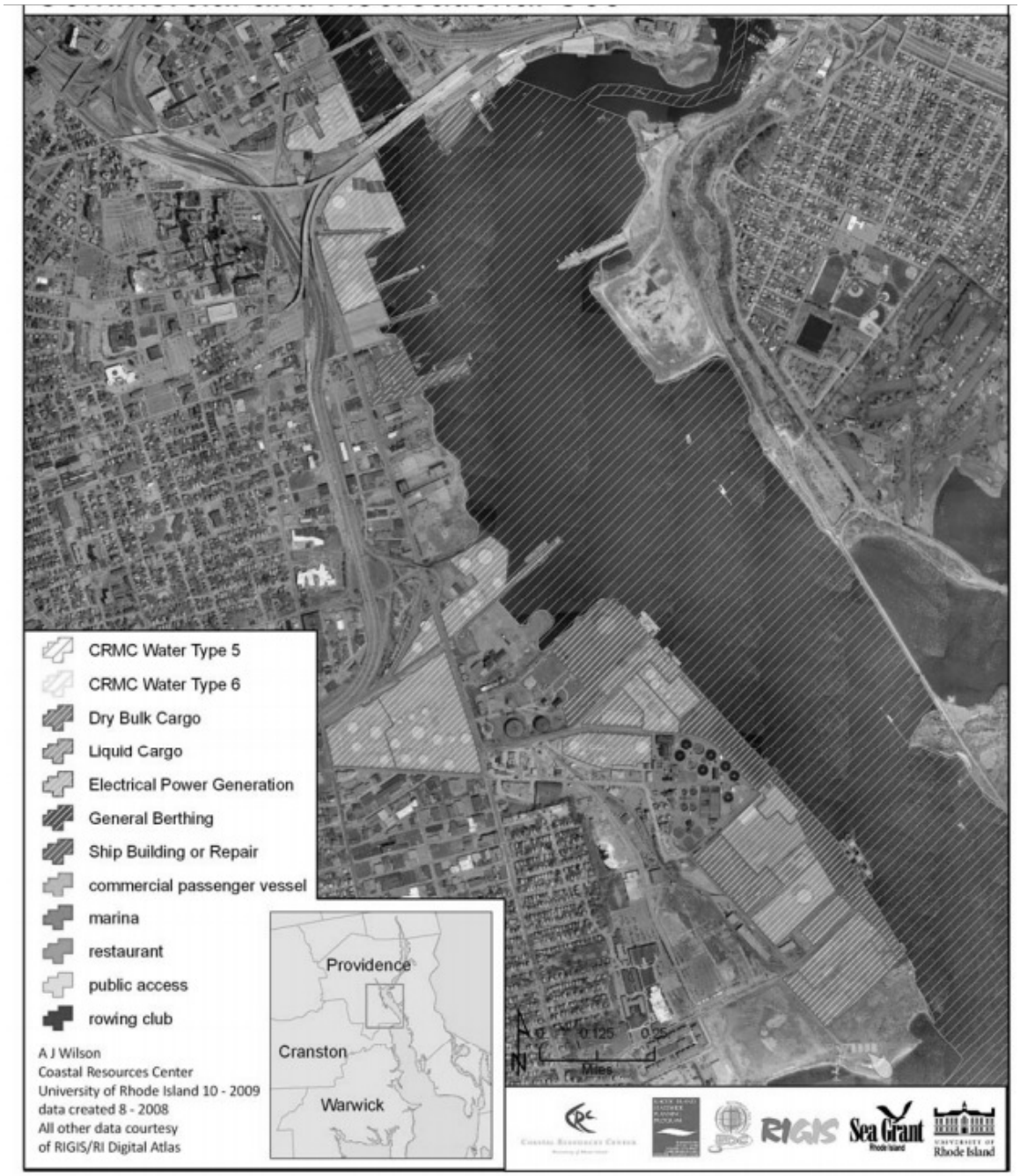

Figure 7 -- Providence Harbor and its water dependent uses (Becker et al. 2010)

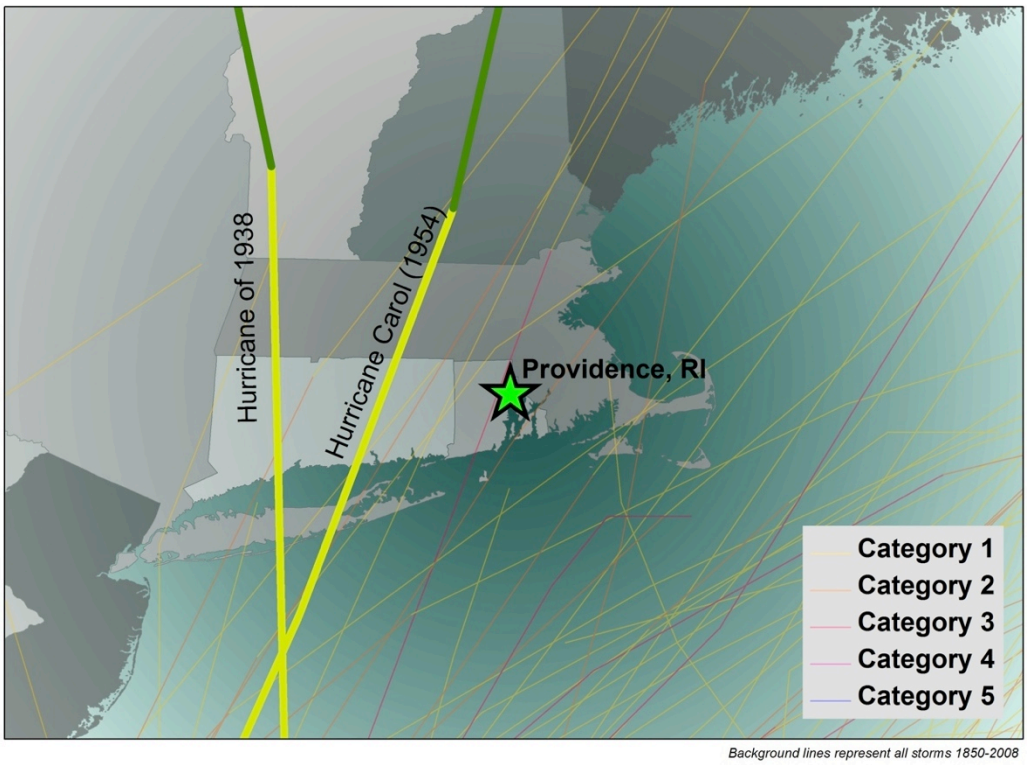

Figure 8 -- Providence and History of Storm Tracks

Figure 9 -- Port of Gulfport with simulated Category 4 storm surge

Figure 10 -- Port of Providence with simulated Category 3 storm surge

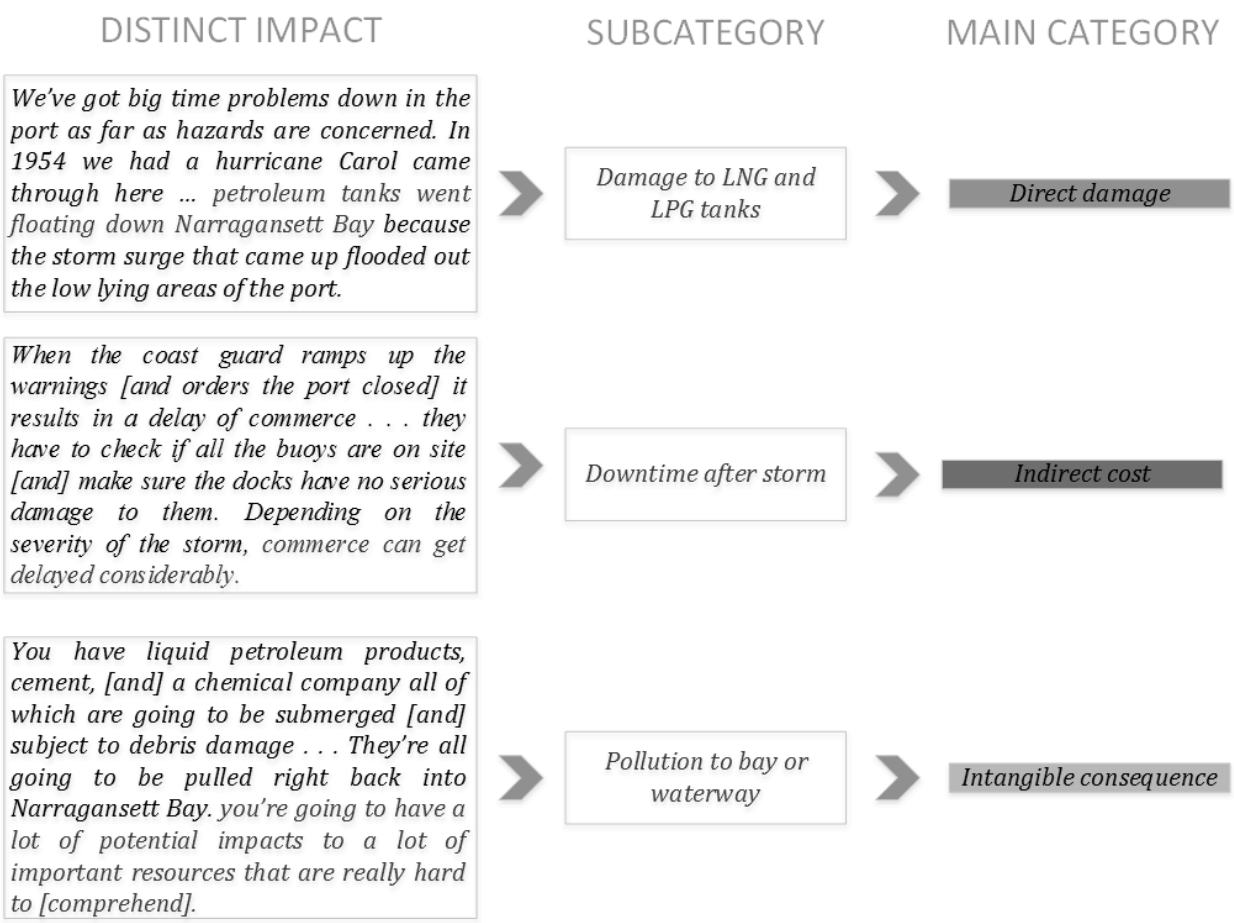

Figure 11 -- Method of coding

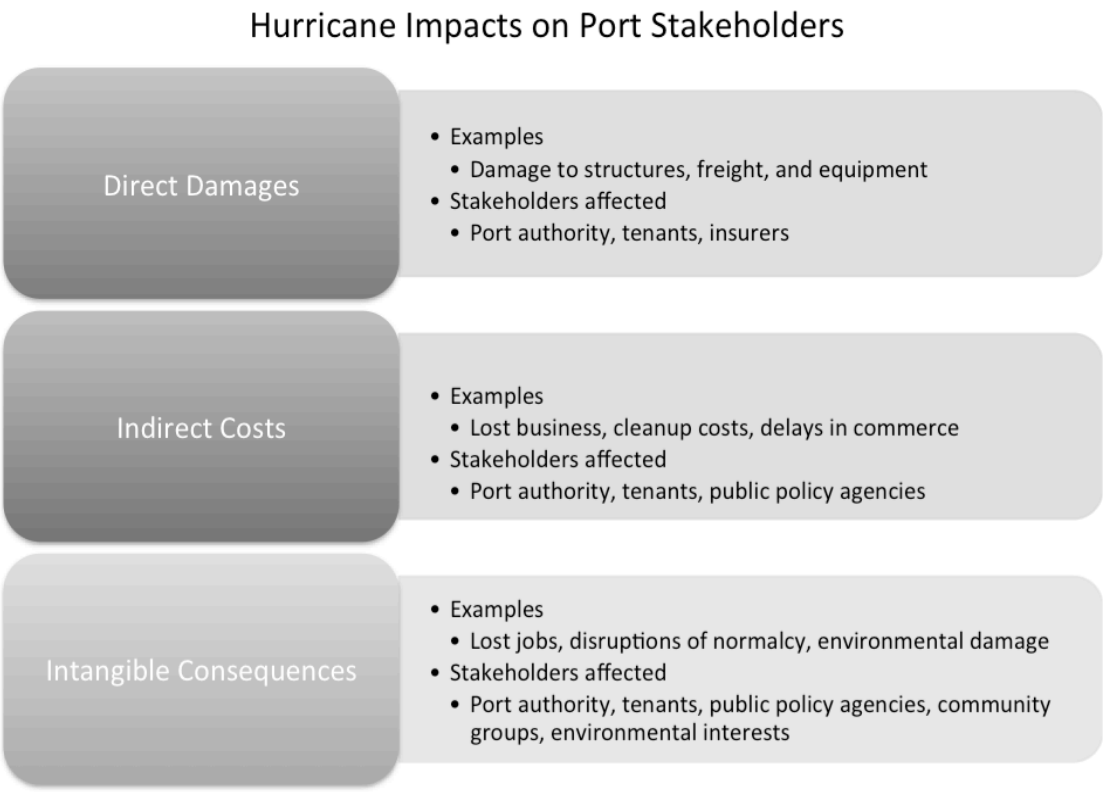

Figure 12 -- Hurricane impacts on port stakeholders

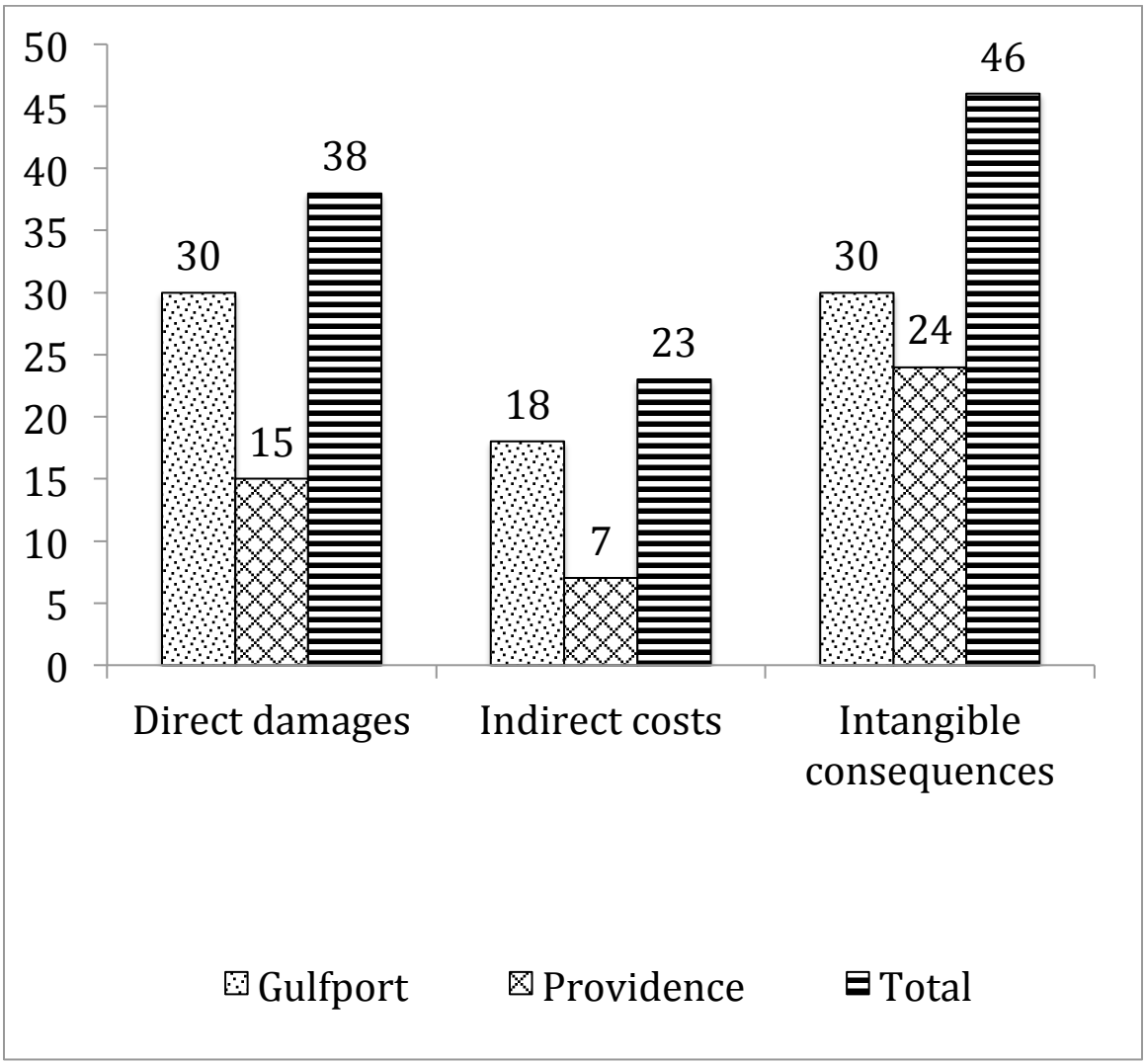

Figure 13 -- Unique impacts mentioned in Gulfport and Providence

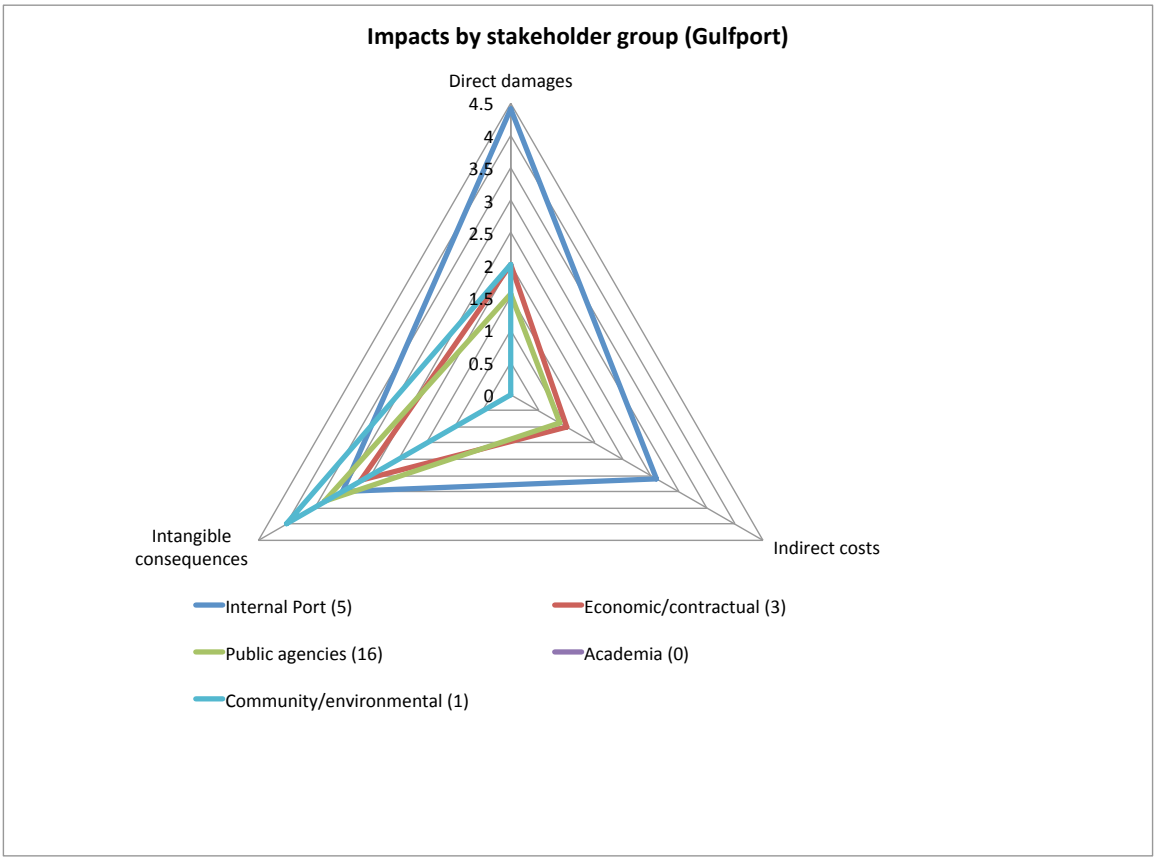

Figure 14 -- Impacts by stakeholder group (Gulfport)

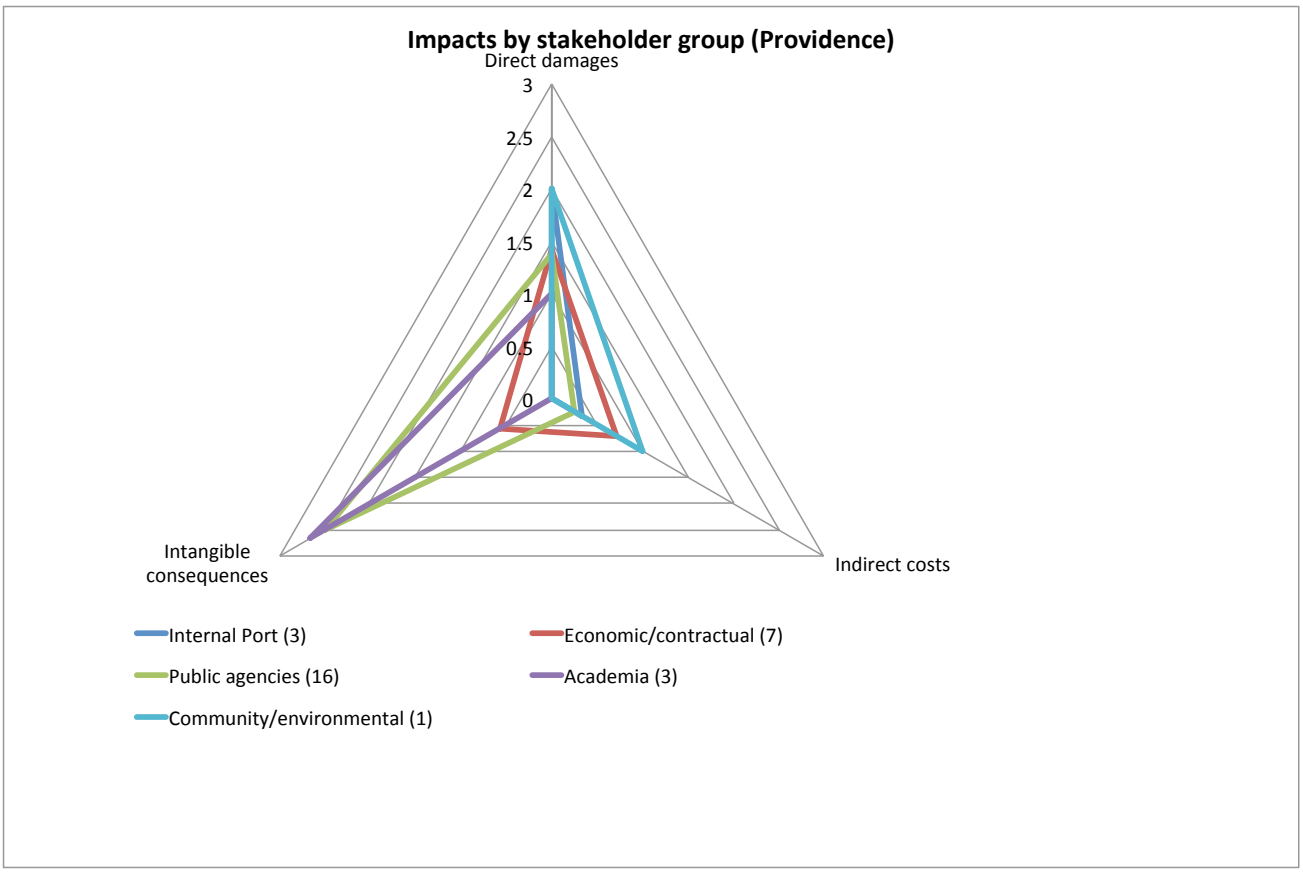

Figure 15 -- Impacts by stakeholder group (Providence)

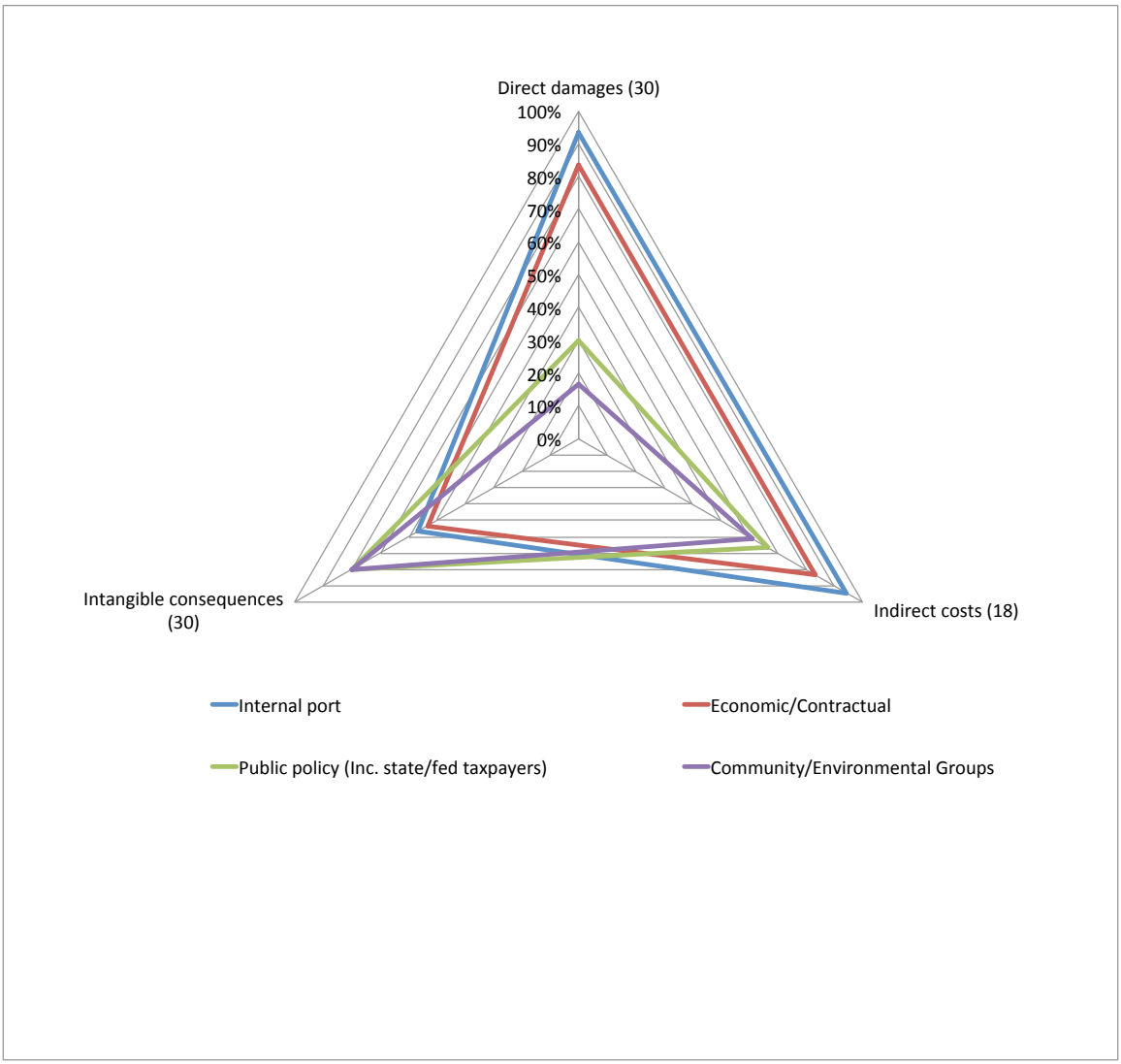

Figure 16 -- Costs upon stakeholders (Gulfport)

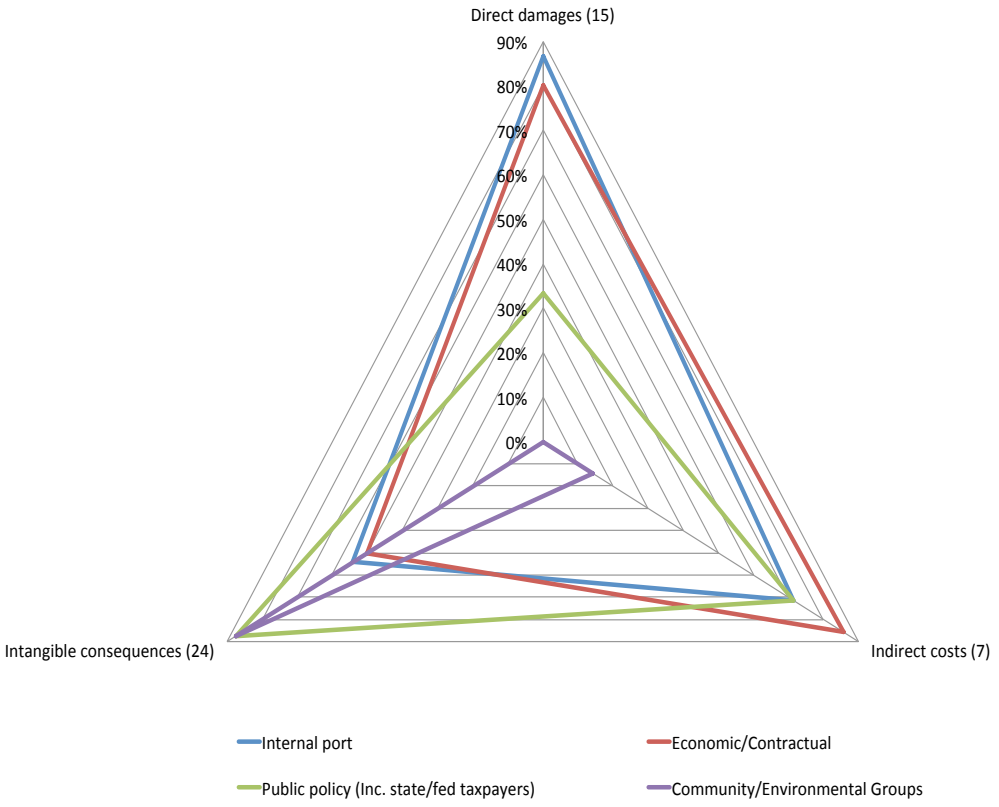

Figure 17 -- Costs upon stakeholders (Providence)

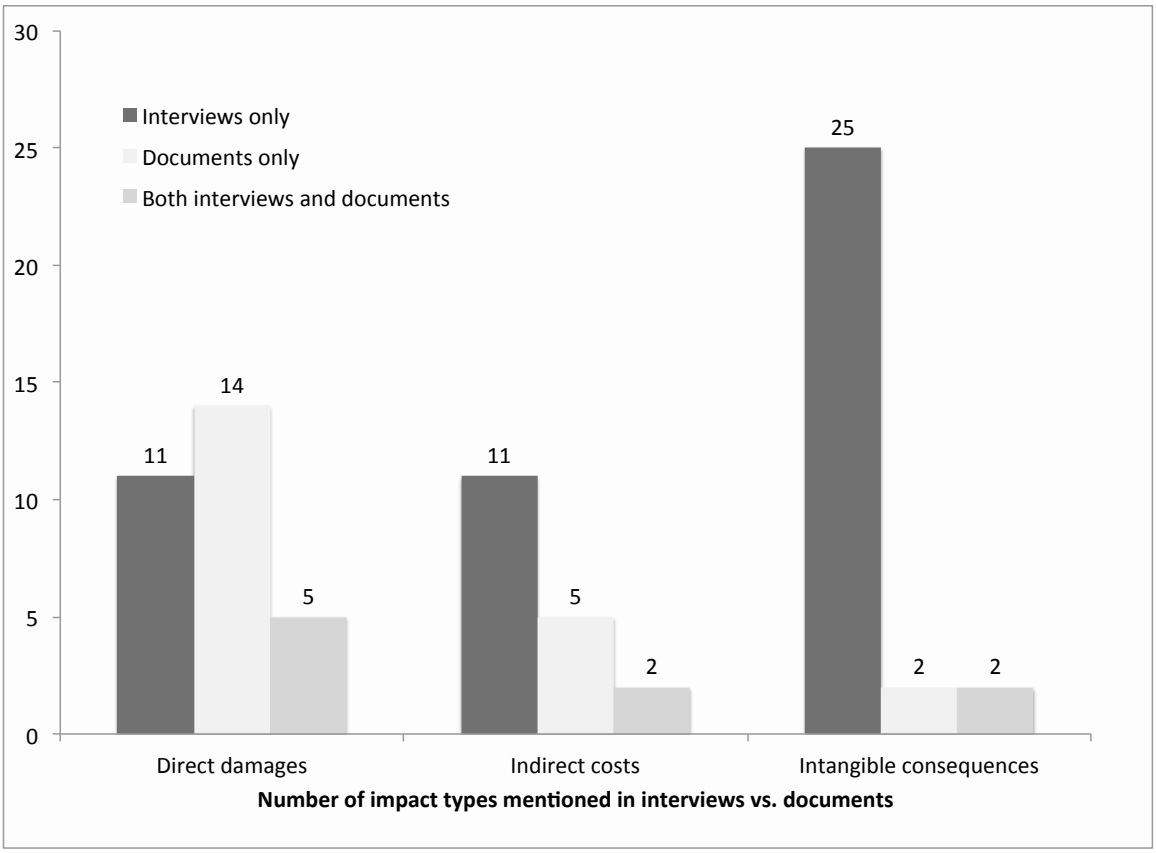

Figure 18 -- Impacts mentioned in interviews vs. documents (Gulfport)

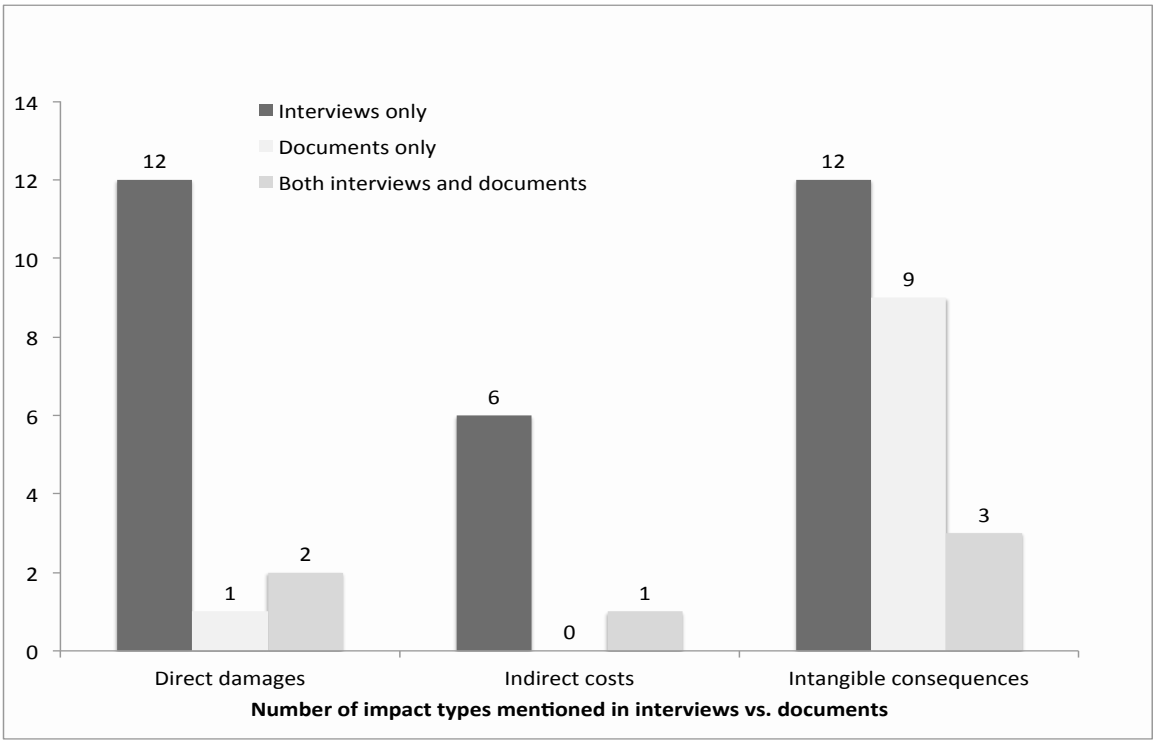

Figure 19 -- Impacts mentioned in interviews vs. documents (Providence

TABLES

Table 1 -- Port of Gulfport statistics

Throughput in tons	Throughput in TEUs	Primary freight	Hurricane probability	Highest recorded storm surge (Year)	Last major storm	# Of hurricanes 1858-2009
2,200,000 (2011)	216,156 (2011)	Containers Bulk Break-bulk	High	30 feet (2005)	2005 (Katrina – Cat 3)	25

Table 2 -- Assessed damages to the Port of Gulfport (PEER 2006)

Asset value prior to Hurricane Katrina	$127,573,778
Post-Katrina [2006] tonnage as compared to Pre-Katrina Tonnage for September -- December 2004	69%
Effect on staffing	Retained 100% of staff
Effect on revenues	Decreased by 70%
Types of [direct] damage	Damaged or destroyed port buildings and warehouses; damaged warehouses;
Direct damage assessment	$50,556,175
Anticipated source of funding for repairs (2006)	Port funds, FEMA, and insurance

Table 3 – Organizations consulted in Gulfport's Environmental Assessment for port restoration

List of Sources, Agencies and Persons Consulted [40 CFR 1508.9(b)]
Mississippi Band of Choctaw Indians-Tribal Historic Preservation Officer
Mississippi Department of Archives and History
Mississippi Department of Environmental Quality-Air Quality Branch
Mississippi Department of Environmental Quality-Hazardous Waste Branch
Mississippi Department of Environmental Quality-Water Quality Branch
Mississippi Department of Marine Resources
Mississippi Department of Transportation
Mississippi Department of Wildlife, Fisheries, and Parks
Mississippi Development Authority/CDBG Disaster Recovery Program
Mississippi Emergency Management Agency
Mississippi State Port Authority
Harrison County Board of Supervisors
Harrison County Utility Authority
City of Gulfport-Planning
City of Gulfport-Floodplain Manager
Federal Emergency Management Agency
U.S. Department of Agriculture-Natural Resources Conservation Service
U.S. Army Corps of Engineers-Mobile District
U.S. Department of Interior-U.S. Fish & Wildlife Service
U.S. Department of Commerce-National Marine Fisheries Service
U.S. Environmental Protection Agency
BMI Environmental

Table 4 -- Timeline for port resilience strategies in Gulfport

YEAR	DECISION	ACTION	ACTORS
1998	Expand port by 84 Acres		MSPA, MDA
2003		Complete 2003 Master Plan	AECOM, MSPA, Governor (Gov.)
2003		Begin filling 60 of 84 acres as per 2003 Master Plan	MSPA
2005	***HURRICANE KATRINA DESTROYS PORT***		
2005	Identify resilience strategies / revisit expansion plan Choose "Evacuation model" as resilience strategy		Governor, MSPS, AECOM
2006		MS applies for $600m funding from HUD to support restoration and resilience	Gov., MSPA, MDA
2006		Update 2003 Master Plan and incorporate new evacuation model as resilience strategy	Gov., MSPA, MDA, AECOM
2007		MS obtains $600m for CDBG/HUD funding in support of Restoration Program	Gov., MDA
2007		2007 – MSPA hires CH2M Hill to review and implement the revised 2007 Port Master Plan	MSPA, CH2M Hill, Gov
2007	Review 2007 Master Plan Update, reject evacuation strategy and create new 25' elevation strategy		Gov., MSPA, MDA, CH2M Hill
2007	MSPA begins additional "Expansion Program" component be completed in conjunction with "Restoration Program"		Gov., MSPA, MDA
2010		MSPA and MDA conduct Environmental Assessment for Restoration Program	MSPA, MDA, HUD
2010		MSPA and MDA conduct Environmental Impact Statement for Expansion Program	MSPA, MDA, USACE
2011		Complete 60 acre fill, begin 24 acre fill and elevation	MSPA
2012	Abandon plan to elevate port	Redirect $140 million to channel dredging project	MSPA

Table 5 -- Stakeholders interviewed in Gulfport

Stakeholders	Organization interviewed	Port interests	Interviews
	Internal Stakeholders		
Internal port stakeholders	Mississippi State Port Authority (MSPA)	*Make port an economic engine for the state, provide jobs*	3
	Mississippi Development Authority (MDA)	*Make port an economic engine for the state, provide jobs, oversee long-term planning for port*	1
	CH2M Hill (Contracted by MSPA)	*Provide program management and support for restoration project*	1
	External Stakeholders		
External economic/contractual stakeholders	Port tenants (Chiquita, Dole, Crowley, DuPont, Island View Casino)	*Port user, supply fruit to customers*	1
	Steward Sneed Insurance	*Manage risk and protect port assets*	2
	Kansas City Southern Railroad		0
Public policy (federal)	US Coast Guard (USCG)	*Facilitate the navigational needs of the port and shipping, facilitate storm operations*	1
	US Army Corps of Engineers (USACE)	*Facilitate maritime commerce, protect marine resources, maintain ship channel*	2
	US Federal Emergency Management Agency (FEMA)	*Facilitate disaster preparation, mitigation, response, and recovery*	5
	National Oceanic and Atmospheric Association (NOAA)	*Provide weather and climate data*	1
	US Customs		0
	State Senate (Senator Wicker)		0
	Environmental Protection Agency		0
Public policy (state)	Gulf Regional Planning Commission	*Long range planning for regional transportation system*	1
	Gulf of Mexico Alliance (GOMA)	*Coastal community resilience*	1
	Mississippi Emergency Management Agency (MEMA)	*Review port project applications*	3
	Mississippi Department of Transportation (MDOT)	*Construction and maintenance of connecting infrastructure*	1
	Mississippi Department of Marine Resources (MDMR)	*Activities at the port that impact coastal waters or wetlands*	3
Public policy (local)	Harrison County Civil Defense	*Facilitate local emergency response, including evacuations*	1
	City of Gulfport	*Represent citizens of the city in port decisions*	1
	Southern Mississippi Planning and Development	*Grant facilitation for transportation project adjacent to port*	1
Community groups	STEPS Neighborhood Group	*Protect adjacent communities, advocate for jobs growth*	1

Table 6 -- Stakeholders interviewed in Providence

Stakeholders	Organization interviewed	Port interests	Interviews
Internal Stakeholders			
Internal Stakeholders	Waterson Terminal Services	*Generate profit*	3
External Stakeholders			
Economic/contractual/ private firms	Univar	*Port tenant*	1
	Affiliated Insurance Managers	*Reduce risks and liability*	1
	Moran Shipping Agency	*Service port and users*	2
	Promet Marine Services	*Repairs to ships and docks*	1
	Marine Pilots Association	*Pilots all commercial traffic to/from the port*	0
	Rhode Island Oil Heat Institute	*Represent petroleum companies at the port*	0
Public policy (Federal)	US Coast Guard	*Facilitate maritime commerce, protect marine resources, maintain ship channel*	1
	US Army Corps of Engineers	*Facilitate maritime commerce, protect marine resources, maintain ship channel*	2
	National Flood Insurance Program	*Facilitate disaster preparation, mitigation, response, and recovery*	1
Public policy (State)	RI Coastal Resources Management Council	*Regulate coastal zone*	3
	RI Statewide Planning	*Transportation and land use planning*	1
	RI Economic Development Corporation	*Generate jobs, economic development*	1
	RI Dept. of Transportation	*Maintain/improve highways/bridges*	1
	RI Dept. of Env. Management	*Environmental concerns*	1
	RI State Senate		1
Public policy (local)	Providence Planning Dept.	*Promote city interests, generate taxes, zoning*	1
	Providence Emergency Management Agency	*Emergency response*	1
	Providence Fire Dept.	*Emergency response*	1
Community	Save the Bay	*Protect adjacent communities, advocate for jobs growth*	1
Academic	Brown University	*Provide research capabilities*	1
	RI Coastal Resources Center	*Provide research capabilities*	1
	URI	*Provide research capabilities*	1

Table 7 -- Documents reviewed from Gulfport

	Title	Author	Sponsor organization	Sector	Type of document	Year
1	*Gulfport Master Plan Update 2007 Final Report*	BDMJM Harris and AECOM	MSPA	Port and private	Master Plan	2007
2	*The Impact of Hurricane Katrina on Mississippi's Commercial Public Ports and Opportunities for Expansion of the Ports*	PEER	Mississippi Legislature	Public (local, state, regional)	Report	2006
3	*Hurricane Katrina Damage Assessment Report*	MSPA	MSPA	Port and private	Damage assessment	2005
4	*Port of Gulfport Restoration Program Action Plan*	MSPA	MSPA	Port and private	Master Plan	2008
5	*Master Planning the Port of Gulfport, Mississippi - Rebirth after Katrina*	John Webb	MSPA	Port and private	Report	2007
6	*Hurricanes Katrina and Rita - Implications for Hurricane Science and Engineering*	Building and Fire Research Laboratory NIST	National Science Board	Public (federal)	Report	2006
7	*Environmental Environmental Assessment and Environmental Review Record for Community Development Block Grant Disaster Recovery Project at State Port at Gulfport*	MSPA	MDA	Port and private	Environmental Assessment	2010
8	*Hurricane Katrina Storm Surge Reconnaissance*	Fritz et al	Georgia Tech	Academia and non-profit	Academic paper	2008
9	*Read the Port of Gulfport's Restoration Program Description*	MSPA	MSPA	Port and private	Press Release	2008
10	*Sustainable Restoration of the Port of Gulfport*	Reilly Morse	Mississippi Center for Justice	Academia and non-profit	Report	2011
11	*The Plan for the Implementation of the Port of Gulfport Restoration Program*	CH2M Hill	MSPA	Port and private	Master Plan	2010
12	*Advancing in the Aftermath IV:*	Loren C. Scott	Capital One N.A.	Academia and non-profit	Report	2007
13	*Letter of opposition to HUD funding*	Multiple	STEPS	Academia and non-profit	Letter of opposition	2007
14	*Maritime Severe Weather Contingency Port Plan*	USCG	USCG	Public (federal)	Hazard mitigation plan	2010
15	*Central Harrison County Connector Highway*	MDOT	MDOT	Public (local, state, regional)	FAQ	2007
16	*Testimony of Governor Haley Barbour*	Haley Barbour	Ad Hoc Subcommittee on Disaster Recovery	Public (local, state, regional)	Testimony	2009
17	*Port of Gulfport Restoration Program Presubmittal Meeting*	CH2M Hill	MSPA	Port and private	Presentation	2009
18	*State of Mississippi Hazard Mitigation Plan*	State of MS	MEMA	Public (local, state, regional)	Hazard mitigation plan	2007
	DOCUMENTS NOT ANALYZED					
19	*Federal Disaster Recovery Grant Report*	MDA	MDA	Port and private	Grant report	2011
20	*Gulfport Restoration Program Action Plan - Amendment 5 - Modification 1*	MSPA	MSPA	Port and private	Port planning document	2008
21	*MSPA Current and Projected Jobs*	MSPA	MSPA	Port and private	Report	2011
22	*Question received on "request for ideas" proposal*	MSPA	MSPA	Port and private	Response to public comment	2010
23	*The Projected Economic Impacts from Container Terminal Development at Gulfport*	TranSystems	MSPA	Port and private	Economic assessment	2011
24	*Mississippi Unified Long-Range Transportation Infrastructure Plan*	MDOT	MDOT	Public (local, state, regional)	Transport Plan	2007
25	*State of Mississippi Budget 2011*	Joint Legislative Budget Committee	Joint Legislative Budget Committee	Public (local, state, regional)	Budget	2011
26	*Mississippi Pay Now, Pay Later:*	American Security Project	American Security Project	Academia and non-profit	Pamphlet	2011
27	*Hurricane Katrina: Profile of a Super Cat Lessons and Implications for Catastrophe Risk Management*	Risk Management Solutions	Risk Management Solutions	Port and private	Report	2005
28	*Harrison County Flood Insurance Study*	FEMA	FEMA	Public (federal)	Flood insurance study	2009
29	*Mississippi Coastal Analysis Project - Coastal Documentation and Main Engineering Report*	FEMA	FEMA	Public (federal)	Report	2008
30	*Mississippi Coastal Improvements Project, Interim Report*	USACE	USACE	Public (federal)	Report	2006
31	*City of Gulfport Budget 2011*	City of Gulfport	City of Gulfport	Public (local, state, regional)	Budget	2011
32	*Harrison County Hurricane Surge Map*	FEMA	FEMA	Public (federal)	Flood insurance study	2009

(Green background indicates document analyzed and coded)

Table 8 -- Documents reviewed in Providence

	Title	Author	Sponsor organization	Sector	Type of document	Year
	DOCUMENTS ANALYZED					
1	*Natural Hazards: Hurricanes, Floods, and Sea Level Rise in theMetro Bay Region Special Area Management Plan*	Pam Rubinoff	Ri CRMC	Public (local, state, regional)	Policy	2009
2	*Strategy for Reducing Risks from Natural Hazards in Providence, Rhode Island: A Multi-Hazard Mitigation Plan*	City of Providence Local Hazard Mitigation Committee, Maguire Group, Inc.	Rhode Island Emergency Management Agency	Public (local, state, regional)	Hazard mitigation plan	2011
3	*Bays, Rivers, and Watersheds Systems-Level Plan: 2009-1013*	Ames Colt	Rhode Island Bays, Rivers, and Watersheds Coordination Team	Public (local, state, regional)	State planning document	2008
4	*Promet Marine Services Hurricane Preparedness Checklist*	Promet Marine Services	Promet Marine Services	Port and private	Hazard mitigation plan	2011
5	*Hazard Identification and Risk Assessment*	Providence Emergency Management Agency	Providence Emergency Management Agency	Public (local, state, regional)	Report	2010
6	*Rhode Island State Hazard Mitigation Plan*	Rhode Island Emergency Management Agency	Rhode Island Emergency Management Agency	Public (local, state, regional)	Hazard mitigation plan	2009
	DOCUMENTS NOT ANALYZED					
7	*Beyond No Regrets: Assessing the Economic Efficiency of Climate Adaptation in Rhode Island*	Kyle A. Polar	Brown University	Academia and non-profit	Student Report	2010
8	*Summary: Preliminary Assessment of Rhode Island's Vulnerability to Climate Change and its Options for Adaptation Action*	Timmons Roberts et al	Brown University	Academia and non-profit	Report	2010
9	*Economic Effects of Allens Avenue Businesses*	FXM Associates	Providence Working Waterfront Alliance	Port and private	Economic assessment	2008
10	*National Infrastructure Protection Plan*	Unassigned	Dept. of Homeland Security	Public (federal)	Planning document	2009
11	*Rhode Island and Southeastern Massachusetts Area Contingency Plan*	Rhode Island and Southeastern Massachusetts Area Committee	USCG	Public (federal)	Hazard mitigation plan	2010
12	*Rhode Island Hurricane Evacuation Study Technical Report*	USACE	USACE	Public (federal)	Report	1995
13	*FY07 Economic Monitoring Report*	Ri Economic Monitoring Collaborative	Ri Bays, Rivers and Watersheds Coordination Team	Public (local, state, regional)	Report	2007
14	*Rhode Island's Ports and Commercial Harbors: A GIS Inventory of Current Uses and Infrastructure*	Jennifer McCann	Rhode Island Statewide Planning	Public (local, state, regional)	Report	2011
15	Rhode Island Pay Now Pay Later	American Security Project	American Security Project	Academia and non-profit	Pamphlet	2011
16	*Natural Hazards and Flood Plain Management in Upper Narragansett Bay*	Malcolm Spaulding, James Hu, Christopher Baxter	University of Rhode Island	Academia and non-profit	Student Report	2007

(Green background indicates document was analyzed and coded)

Table 9 -- Table of direct damages

DIRECT DAMAGES KEY I = Mentioned in interviews D = Mentioned in documents B = Mentioned in interviews AND documents $ = Cost borned by stakeholder group	Internal port	Economic/Contractual	Public policy (Inc. state/fed taxpayers)	Community/Environmental Groups	Gulfport	Providence
Damage to wharfs, docks, and berthing areas					B	B
Boats sinking at docks and cost to remove them	$	$	$			I
Damage due to stress on vessel mooring systems	$	$				I
Damage to wharf, piers, docks	$				B	B
Fill eroded around berths	$	$			D	
Rail cars ended up in ship berths	$	$	$	$	I	
Damage to vessels and barges					D	
Casino barge broke free	$	$			D	
Damage to port utilities and systems					B	
Utility damage (general)	$	$			D	
Sewer lines down	$	$			I	
Power loss	$	$			I	
Mechanical and electrical system damage	$	$			D	
Damage to port roads and rail lines					D	
Damage to port lands					I	
Damage to construction projects underway	$	$			I	
Erosion of filled land	$					I
Damage to port facilities (general)					B	D
Total losses at all MS ports 99.9 million	$	$	$		D	
Specific port damage figures	$	$	$		D	
General damage mention	$	$	$		D	D
Cost of rebuilding	$	$	$		I	
Damage to port equipment					B	I
Fencing system damage	$				D	
Damage to port equipment	$				B	I
Damage to cranes	$				D	

	Internal port	Economic/Contractual	Public policy (Inc. state/fed taxpayers)	Community/Environmental Groups	Gulfport	Providence
Damage to port buildings and structures					B	
Damage to casino	$	$			B	
Damage to fire system water tower	$	$			I	
Damage to LNG and LPG tanks	$	$				I
Damage to parking structure	$	$			D	
Damage to warehouses, office, structures	$	$			B	I
Debris causing damage to structures	$	$			D	I
Flooding damage to buildings	$	$			I	I
Fuel tanks breached	$	$				I
Roofs blown off	$	$			I	
Tanks floating free	$	$	$			I
Warehouse floors blown up from pressure	$	$			I	
Damaged freight and cargo					B	I
Lost or damaged freight and cargo		$			B	I
Containers washed inland	$	$	$	$	D	
Damage caused by debris off port property					B	
Debris field	$	$	$	$	D	
Cost to clean up debris	$	$	$	$	I	
Containers all over city	$	$	$	$	I	
Damage off port property						B
Damage to off-port roads and rail lines		$	$			B
Transportation sector (general)	$	$	$			I

Table 10 -- Table of indirect costs

INDIRECT COSTS KEY I = Mentioned in interviews D = Mentioned in documents B = Mentioned in interviews AND documents $ = Cost borned by stakeholder group	Internal port	Economic/Contractual	Public policy (Inc. state/fed taxpayers)	Community/Environmental Groups	Gulfport	Providence
Lost business for port and port tenants						
Tonnage decline	$	$	$	$	D	
Lost tenants	$	$	$		B	
Lost revenue to port businesses	$	$	$	$	D	
Casino losses	$	$		$	D	
Delays in port-related commerce and increased prices						
Loss of facilities at port	$	$		$	D	
Downtime after storm	$	$	$	$	I	I
Cost of materials goes up due to port shutdown	$	$	$	$	I	
Cost to re-dredge, clear, and re-open navigation channel	$		$	$	B	
Port closed to navigation	$	$	$		I	I
Navigation channel closed	$		$		I	
General business continuity problems	$	$	$			B
Fisheries losses		$				I
Debris impacts to navigation	$	$	$			I
Cleanup costs, emergency workers, emergency services, etc.						
Housing costs for relief workers	$	$	$		I	
Costs to the state (cleanup, emergency services, etc.)			$		I	
Costs to replace buoys moved off station			$			I
Other hurricane-related costs for port and tenants						
Port evacuation cost	$	$		$	I	
Overtime pay	$	$	$	$	I	
Lawsuits against the port and tenants	$	$		$	I	
Insurance costs going up	$	$		$	I	
Carriers need to move equipment to other ports	$	$			I	
Positive spillovers						
Accelerated redevelopment and opened markets	$	$	$		D	
New business can result from catastrophic event	$	$				I

Table 11 -- Table of intangible consequences

INTANGIBLE CONSEQUENCES KEY I = Mentioned in interviews D = Mentioned in documents B = Mentioned in interviews AND documents $ = Cost borned by stakeholder group	Internal port	Economic/Contractual	Public policy (Inc. state/fed taxpayers)	Community/Environmental Groups	Gulfport	Providence
Labor and employment consequences						
Workers stranded at port	✓	✓	✓	✓	I	
Unemployment insurance lost	✓	✓	✓	✓	I	
Lost jobs	✓	✓	✓	✓	D	
Fluctuations in supply and demand of labor pool	✓	✓	✓	✓	I	
Emotional toll on staff	✓	✓	✓	✓	I	
General disruptions to sense of normalcy and quality of life						
Population shifts	✓	✓	✓	✓	I	
Disruption of energy supplies (LNG, LPG, Fuel)	✓	✓	✓	✓	I	I
Scale of disaster is overwhelming	✓	✓	✓	✓		I
Environmental damages to waterways, ecosystems, and coastal land resulting from release of materials stored at port						
Pollution to bay or waterway			✓	✓	I	B
Hazardous materials impacting sediments			✓	✓	I	
Loss of coastal wetlands and ecosystems damages	✓		✓	✓	I	I
Coastal land damages	✓		✓	✓	I	
Cement into the channel			✓	✓		I
Coal washed into water			✓	✓		I
Contamination caused by inundation			✓	✓		D
Liquid asphalt into the waterway			✓	✓		I
Difficulty in planning and development						
Pre-storm business plans derailed	✓	✓			I	
Fluctuations in freight patterns	✓	✓			I	
Difficulties in obtaining insurance						
Risks become uninsurable	✓	✓			I	I
Moratorium on new insurance policies		✓			I	
Damage at the port prevents more efficient disaster response for region			✓	✓		
Can't use port for as recovery and response platform to aid region			✓	✓	I	D
Debris hampers emergency and repair crews	✓	✓	✓	✓		D
Surveying and navigation recovery equipment in short supply			✓	✓		I

	Internal port	Economic/Contractual	Public policy (Inc. state/fed taxpayers)	Community/Environmental Groups	Gulfport	Providence
Consequences of debris						
Debris in waterway obstructs navigation and hinders dredging			✓	✓	I	B
Debris gets reported and recorded causing paperwork logjam			✓	✓	i	
Debris from port ends up as battering ram causing other damage	✓	✓	✓	✓	I	
Debris damming up marshes and wetlands and preventing normal tidal flushing			✓	✓	I	
Debris as pollution			✓	✓	I	
Debris as negative impact on residential quality of life			✓	✓	I	
Debris as a general problem			✓	✓	B	B
Consequence for the local and regional economy from losing port functionality						
Supply chain interruptions	✓	✓	✓	✓	I	I
Role of ports in state economy			✓	✓	D	
Lost jobs devastate local economy			✓	✓	I	
Local economy suffers (general)			✓	✓	I	
Lost jobs devastate local economy						I
Small businesses forced out of business due to recovery costs						I
Business operational burdens						
Operations continuity	✓	✓			I	
Lost business records	✓	✓			B	
Forced to work from temporary facilities	✓	✓			B	
Long recovery times	✓	✓	✓	✓		I
Port facility closures	✓	✓	✓	✓		D
Disruption of critical services	✓	✓	✓	✓		
Destruction of energy infrastructure	✓	✓	✓	✓		D
Disruption of regional energy distribution	✓	✓	✓	✓		D
Interruption of critical goods supply	✓	✓	✓	✓		D
Interruption of essential services	✓	✓	✓	✓		D
Interruption of power supply	✓	✓	✓	✓		D

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