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Public perceptions of the functions of natural and engineered infrastructure in coastal hazards mitigation: the cases of two communities in the Raritan bayshore, New Jersey

Jaime D. Ewalt Gray
New Jersey Institute of Technology

ABSTRACT

PUBLIC PERCEPTIONS OF THE FUNCTIONS OF NATURAL AND ENGINEERED INFRASTRUCTURE IN COASTAL HAZARDS MITIGATION: THE CASES OF TWO COMMUNITIES IN THE RARITAN BAYSHORE, NEW JERSEY

by
Jaime D. Ewalt Gray

Emerging United States (U.S.) federal policies call for more comprehensive integration of both engineered and natural infrastructure in mitigating coastal hazards. For such policies to be effectively implemented, the mitigation functions of and relationship between natural infrastructure and engineered infrastructure must be understood and their integrated use accepted by affected actors, especially residents living in at-risk coastal communities. Little is known about public perceptions of the functions of engineered and natural infrastructure in coastal hazard mitigation and the interactions between these two types of infrastructure. This study analyzes perceptions based on semi-structured interviews of 14 residents in Laurence Harbor, Middlesex County and 13 residents in Union Beach, Monmouth County, New Jersey. Interview questions solicit participants' awareness and perceptions of how the two types of infrastructure affect the hazards of flooding, erosion, and storms. Photographs of engineered and natural infrastructure in each community are shown to prompt participants' comments about the functions and possible interactions between the two types of infrastructure. Thematic content analysis is used to analyze these interviews to understand participants' awareness and perceptions of both types of infrastructure and their preferences for using each type of infrastructure in mitigating coastal hazards.

Laurence Harbor and Union Beach are located on the shore of Raritan Bay, New Jersey and were significantly impacted by Superstorm Sandy in 2012. The two communities have similar mitigation infrastructure but different experiences with coastal hazards: flooding is the primary hazard in Union Beach and erosion is the major concern in Laurence Harbor. This study finds that participants' awareness and perceptions differ as a result of their local experiences with coastal hazards. Participants in Laurence Harbor are more aware of existing local mitigation infrastructure than are participants in Union Beach. Perceptions of the functions of both types of infrastructure of participants in Laurence Harbor are also more similar to the assessments of scientists and engineers than are the perceptions of participants in Union Beach.

Participants' preferences for the use of specific type of infrastructure are related to their perceptions about the ability of each type of infrastructure to mitigate coastal hazards. The ancillary benefits of each infrastructure type, such as aesthetics, recreation, and ecological value, are also related to the preferences for participants in Laurence Harbor. Although participants broadly understand the functions of the two types of mitigation infrastructure, they are less aware of the interactions between them. Education and outreach should be targeted to improve the public understanding of the ways that natural and engineered infrastructure interact in coastal hazard mitigation. Results of this study could improve the governance process of coastal hazard mitigation by informing all governance actors about the value of drawing on residents' current knowledge of local mitigation infrastructure.

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by
Jaime D. Ewalt Gray

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BIOGRAPHICAL SKETCH

Author: Jaime D. Ewalt Gray

Degree: Doctor of Philosophy

Date: January 2017

Graduate and Undergraduate Education:

- Doctor of Philosophy in Environmental Science,
  New Jersey Institute of Technology, Newark, NJ, 2017

- Master of Science in Biochemistry,
  The Ohio State University, Columbus, OH, 2003

- Bachelor of Science in Biology and Biochemistry,
  Syracuse University, Syracuse, NY, 1998

Major: Environmental Science

Publications:

Sathish Rajamani, Moacir Torres, Vanessa Falcao, Jaime Ewalt Gray, Daniel A. Coury, Pio Colepicolo, and Richard Sayre (2014) "Noninvasive Evaluation of Heavy Metal Uptake and Storage in Microalgae Using a Fluorescence Resonance Energy Transfer-Based Heavy Metal Biosensor." *Plant Physiology, 164* (2), 1059-1067 doi: http://dx.doi.org/10.1104/pp.113.229765

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This dissertation is dedicated to my husband, John, who has generously supported and encouraged me in so many ways. John has made many sacrifices and taken on much responsibility to ensure that I could focus on this research. He has been a source of inspiration and a sounding board. Over the years, he has listened to my many ideas and research questions and engaged in fruitful discussions. I thank him for standing by me and imparting wisdom and strength to address the challenges and obstacles in the path to this dissertation. Here's to a new *chapter* in our lives!

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And lastly, I dedicate this dissertation to the constantly curious, those that challenge the status quo, and those that work to raise awareness to the interconnections between our social, economic, political, technical, and environmental decisions.

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

Chapter **Page**

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF ACRONYMS

CRP	Comprehensive Restoration Plan
DOI	Department of the Interior
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Standard
GAO	Government Accountability Office
LH	Laurence Harbor
MSL	mean sea level
MCY	million cubic yards
MHHW	mean higher high water
NOAA	National Oceanic & Atmospheric Administration
NFWF	National Fish and Wildlife Foundation
UB	Union Beach
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

GLOSSARY OF TERMS

Infrastructure	compilation of structures or features
Natural infrastructure	compilation of natural features
Engineered infrastructure	compilation of engineered or built structures
Mitigation infrastructure	compilation of natural features and engineered structures that serve to reduce coastal hazards or impact from coastal hazards
Natural features	ecological area created through physical, biological, geologic, and chemical processes
Engineered structures	physical constructions designed and built by humans; used interchangeably with "built structures"
Built structures	physical constructions erected by humans: used interchangeably with “engineered structures”

CHAPTER 1

INTRODUCTION

1.1 Coastal Hazards and Risk

Coastal regions are popular, populated, profitable, and risky. In 2005, 1.2 billion people, twenty-three percent of the world's population, lived within 100 km of a coastline. By 2030, it is expected that fifty percent of the global population will live in coastal regions (Adger et al., 2005). In the United States (U.S.) alone, over 123 million people, thirty-nine percent of its population, lived in coastal counties in 2010, a thirty-nine percent increase from 1970, with expectations of an eight percent increase by 2020 (NOAA, 2014).

Coastal communities contribute significantly to the economy through tourism, ports, fisheries, and energy production (Kousky, 2012). In the U.S., coastal counties are less than ten percent of its land area but contributed more than $6.6 trillion, nearly half of its gross domestic product, in 2011 (Spalding, Ruffo, et al., 2014). Worldwide, at least $3 trillion of physical assets are located in flood-prone coastal regions; that number is expected to increase to $35 trillion by 2070 (Temmerman et al., 2013). The continued functioning of these highly populated and economically robust regions has been consistently threatened by their exposure and vulnerability to coastal hazards and the resulting risk of negative consequences.

Coastal hazards are storm events and their associated surge, precipitation, and high winds, coastal erosion, shoreline destabilization, and flooding (James K. Mitchell, 2006). These hazards cause widespread damages and negatively affect the people and communities in coastal regions. Hurricane Andrew, a Category 5 storm, caused $26.5 billion in economic damages to the state of Florida in 1992. More recently, Superstorm Sandy resulted in $36.9 billion in direct damage to property and infrastructure and response costs in the State of New Jersey (State of New Jersey, 2012). And, this monetary value does not include the indirect impacts from environmental damages or business interruption or their multiplier effects.

The frequency and intensity of hydro-meteorological hazards affecting coastal areas has been increasing over time worldwide (Parvin et al., 2008) and climate change is heightening the frequency and intensity of natural hazards (Bedsworth et al., 2010; Gedan et al., 2011; Spalding, Ruffo, et al., 2014). For example, in Bangladesh the number of tropical cyclones has tripled over the last fifty years (Parvin et al., 2008).

Not only is the intensity and frequency of coastal hazards increasing, but the risks to coastal communities from coastal hazards are as well. Risk is the probability of a negative consequence such as damage to property and threats to human safety. Risk is a product of a hazard and vulnerability (FEMA, 2011). Coastal risks are a result of coastal hazards, geography, and the physical condition of the coast (J. K. Mitchell, 2006). Increasing coastal erosion, land subsidence, sea level rise, and severity of coastal storms with stronger wave, winds, and surge enhance coastal communities' risk which is compounded by human decisions at the coast, such as the built environment's encroachment on natural protective features (USACE, 2013a; van Slobbe et al., 2013). Santha et al. (2014) refers to the enhanced risk amplified by anthropogenic interventions as "perils at the coast". A coastal community's vulnerability to the negative impacts from coastal hazards is the result of exposure of people and assets to coastal hazards and the effectiveness of existing measures to mitigate those hazards. It is important to understand the coastal hazards and associated risks to coastal communities in order to frame potential interventions, one key one being structural measures to mitigate coastal hazards.

1.2 Coastal Hazard Mitigation Using Structural Measures

Increasing coastal hazards, growing populations, and accumulating assets in coastal regions make it imperative to reduce the risk to coastal communities through various hazard mitigation[1] strategies (Spalding, McIvor, et al., 2014). Strategies to reduce coastal risks can include structural and nonstructural measures[2]. Structural measures specifically seek to mitigate coastal hazards such as flooding and erosion and the impact from storms through either engineered structures and/or reliance on natural infrastructure. Common structural measures include engineering structures to reduce erosion, such as groins, or mitigate the effects of storm surge, such as sea walls (Temmerman et al., 2013). Natural environmental features in coastal areas, such as dunes, maritime forests, and wetlands, also reduce the impact of coastal hazards on communities through flood attenuation and shoreline stabilization (Arkema et al., 2013; Barbier et al., 2011; Gedan et al., 2011; Shepard et al., 2011; Sutton-Grier et al., 2015).

Built structures engineered for purposes of mitigating coastal hazards and natural environmental features that reduce coastal hazards and impact from coastal hazards

[1] The U.S. Federal Emergency Management Agency (FEMA) defines mitigation as a sustained action to reduce or eliminate risk to people or property from hazards and their effects.

[2] Nonstructural measures are used to mitigate risk from coastal hazards and include financial insurance, disaster response planning, land use policies, building codes, or removal of at-risk assets (USACE, 2013; Bedsworth et al., 2010; Mustelin et al., 2010). They are not the subject of this research.

constitute hazard mitigation infrastructure[3] and are considered engineered and natural infrastructure, respectively. Although both engineered and natural infrastructure provide hazard mitigation benefits to coastal communities and may reduce the risk of damage or negative impact from hazards, they function differently in response to coastal hazards. Engineered structures are not self-adaptive, they are designed for a specified hazard condition, thereby requiring modification if hazard conditions change or repair when they fail or are damaged (Schultz et al., 2012). Natural, environmental systems are adaptive to coastal hazards and self-regenerative, require less maintenance than engineered infrastructure, and increase their capacity to mitigate coastal hazards over time (Adger et al., 2005). For these reasons, some scientists suggest that natural infrastructure is more sustainable and cost-effective for coastal hazard mitigation over time than engineered infrastructure (Spalding, Ruffo, et al., 2014; Temmerman et al., 2013). However, sustaining, enhancing, or creating new natural infrastructure is not possible in all coastal areas and, given the increase of coastal hazards, natural infrastructure alone may not be sufficient to mitigate coastal hazards in many coastal areas.

An important consideration when proposing structural intervention to mitigate coastal hazards is that much engineered infrastructure can amplify the negative impacts from coastal hazards through damage to natural infrastructure (enhancing erosion and accelerating coastal wetland loss[4]) (Barbier, 2013; Freudenburg et al., 2008; van Slobbe et al., 2013). Often the negative impacts from engineered infrastructure on natural environmental features are not considered unless engineered infrastructure is designed with

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[3] Infrastructure is the underlying foundation, basic framework, or structures necessary for a system to function (Merriam-Webster).

[4] Engineered infrastructure cuts wetlands off from needed inundation and in many coastal areas prevent wetlands from migrating landward with increasing sea levels (coastal squeeze) (Temmerman et al., 2013).

the natural environment in mind or unless natural features are accounted for in the engineered design.

Integration of Natural and Engineered Infrastructure

Given the increasing risk to coastal communities from coastal hazards, hazard mitigation policies and coastal decisions must take into account the benefits of natural infrastructure and its relationship with engineered infrastructure (USACE, 2013a). The relationship between natural and engineered infrastructure needs to be conceptualized at the level of intervention (the local level) since failure of one type of infrastructure can negatively impact the functioning of the other thus potentially increasing risk to coastal communities from coastal hazards. Some engineering practices integrate features of natural systems into designs to take advantage of their hazard mitigation functions. These practices are defined by the United States Army Corps of Engineers (USACE) as nature-based or green infrastructure (NOAA, 2013; USACE, 2013a). Integrating the use of natural features with engineered infrastructure, whether through protecting or enhancing existing natural infrastructure or creating natural features through nature-based or green infrastructure[5], is considered a cost effective and sustainable strategy[6] for mitigating coastal hazards and enhancing resilience[7] of coastal communities (Schultz et al., 2012).

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[5] Although nature-based and green infrastructure can be considered natural infrastructure for the purposes of discussing hazard mitigation strategies, the subject of this study is existing natural, environmental features, not "engineered natural features".

[6] The long-term viability of engineered natural features, such as green infrastructure, for the purposes of hazard mitigation is not as well-known as that of natural coastal ecosystems.

[7] Buzz Holling introduced the concept of resilience in 1972, recognizing the dynamic interactions between humans and their activities and the natural world (C.S. Holling, 1973). Holling seminally coined "resilience" as the amount of disturbance a system can absorb before changing its structure (Gunderson et al., 2010). Resilience can be thought of as a measure of flexibility in response to a disturbance, such as a coastal hazard (Kahan et al., 2009; Vugrin et al., 2010). Higher resilience would enhance the community's ability to plan for, adapt to, and recover from a disturbance (Gaillard, 2010; Gallopin, 2006; C. S. Holling, 2001; Seeliger et al., 2013; Walker et al., 2002; Walker et al., 2004). Resistance, on the other hand, measures how unyielding the community is to a disturbance (Limburg et al., 2002; Schultz et al., 2012). In engineering practice, the

For more comprehensive hazard mitigation strategies to be implemented these strategies need to be defined and understood by all involved in decision making and supported by the public. Spalding et al. (2014) recommended critical steps for implementing integrated, comprehensive coastal hazard mitigation policy that include, but not be limited to: building the case for the utilization of natural infrastructure; avoiding compartmentalizing natural infrastructure and engineered infrastructure when discussing mitigation strategies; helping communities visualize potential strategies; engaging with all stakeholders; and incorporating proven integrated coastal management strategies such as hybrid approaches.

1.3 Risk Governance, Hazard Mitigation and Public Perceptions

Coastal risks are managed through hazard mitigation decisions and investments guided by a suite of regulations and policies and informed by the knowledge and perspectives of a multitude of actors. Risk governance is the formal and informal processes through which hazard mitigation decisions are made. It includes both the institutional structure and policy processes that guide the collective actions of a community to regulate decisions, reduce coastal hazards, or control risk posed by coastal hazards (Penning-Rowsell et al., 2014; Renn et al., 2011). Risk governance involves laws and regulations, policies, communication practices, investment strategies, and decision making arrangements. It involves assessment, evaluation, management, and communication of hazards and associated risk with the intent to reach commonly acceptable hazard mitigation strategies.

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objective of resiliency is to obtain efficiency, constancy and predictability through, in part, being resistant (Kahan et al., 2009). This contrasts with resilience of natural systems, which requires self-organization and adaptation to preserve functioning when faced with disturbance (Schultz et al., 2012).

The governance of coastal hazards mitigation decisions involves a number of actors from federal, state, and local governments, scientists and engineers, planners, nongovernmental organizations, and the public[8].

All governance actors bring valid, yet different perspectives, interests, and knowledge to the risk governance process (Beierle, 1999). Likewise, the perceptions of coastal hazards, the risks posed, and potential strategies to address will differ among governance actors. The knowledge, interests and perceptions of the governmental and nongovernmental governance actors are important for defining the scale of the coastal hazards and evaluating hazard mitigation strategies. And, although the public in at-risk communities have the first-hand experience of hazards and the risk posed by these hazards, it is scientists and engineers that are typically tasked with defining the problems and developing strategies to address them (Beck, 1992).

The public in at-risk communities should play a critical role in the risk mitigation governance process because of their first-hand knowledge (Penning-Rowsell et al., 2014). Public involvement[9] in the governance process is important since legitimizing decisions requires accountability to the public (Eden, 1996). The public's perceptions of coastal hazard mitigation strategies affect their willingness to support mitigation decisions. The USACE has recognized that one policy challenge for integrating natural infrastructure into

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[8] Nongovernmental organizations such as advocacy and interest groups, industry and business associations, and academic institutions, as well as the public, are involved in the governance process as stakeholders or nongovernmental governance actors.

[9] There are a number of mechanisms by which the governance process involves the public. Most of them one-way communication, with limited decision-making on the part of the public, through public hearings, public comment, public notice, and information sessions (Godschalk et al., 2003). In most cases where coastal hazard mitigation is pursued, the public from communities at risk are engaged at the beginning of the process to raise concerns over risks and demand for risk mitigation actions and/or at the end to comment on the proposed mitigation options (USACE, 2004). Public participation is often relegated to awareness and education, not policy consultation (Eden, 1996). Some means for two-way information sharing take the form of advisory committees, citizen panels, or regulatory negotiation (Beierle, 1999).

engineered designs is communicating and sharing information not just among and within different levels of government but should also address private interests and local residents recognizing the need for better public understanding of how natural infrastructure can increase the resilience of a community (Bridges et al., 2015).

The risk governance process is challenging because hazard mitigation decisions often include technically complex and value-laden issues, involve a multitude of actors, and must be responsive to the citizens that those decisions will affect (Beierle, 1999). Mitigation decisions result from governance actors' perceptions, interests, values, knowledge, and evidence of both risk and alternative strategies for mitigation (Renn et al., 2011). The knowledge of each actor in the governance process is different as a result of resources, experience, discourse, and perceptions (Janssen et al., 2014). A key component for an effective governance process is communication and knowledge sharing among actors.

The governance process should incorporate public values, assumptions, and preferences because this increases the quality of decisions, fosters public trust, and reduces conflict in the governance process (Eden, 1996). Sharing knowledge builds a common language and understanding that bridges the discourse of diverse governance actors resulting in more inclusive decision making (Godschalk et al., 2003). Involving the public in risk mitigation discussions can lead to public support and trust of the governance process, which ultimately helps effectuate mitigation strategies (Eden, 1996).

1.4 Research Objectives

Coastal hazard mitigation is a complex phenomenon and the process of governing coastal hazard mitigation is multifaceted, dynamic and involves various actors. There is scientific knowledge of and recent governmental interest in integrating natural and engineered infrastructure in coastal hazard mitigation strategies. The function of and relationship between engineered and natural infrastructure is understood from a scientific perspective. The pursuit of integrating natural infrastructure into comprehensive coastal hazard mitigation has come from the scientific understanding of the functions of natural infrastructure, backed by environmental interests, and pushed from a federal level but not evident at a local level as a priority. For more integrated and comprehensive mitigation strategies to be implemented, there must be a public appreciation of these strategies which may come from the public's understanding of the role of both kinds of infrastructures and how they affect each other's mitigation function.

Existing research fails to assess comprehensive coastal hazard mitigation from the perspective of at-risk communities. The perceptions of residents living in coastal communities about the function of and relationships between engineered and natural infrastructure is not known. Understanding coastal residents' awareness and perceptions of such hazard mitigation infrastructure should be a key component of the governance process for determining local attitudes, preferences, and aversions to certain coastal hazard mitigation strategies and would thus affect governance decisions. Local coastal communities' perceptions should be deliberately considered in discussions about the utilization of natural and engineered infrastructure for enhancing the resilience of coastal communities to coastal hazards.

This research addresses the limitations of existing literature on coastal hazard mitigation in order to ensure adoption of publicly acceptable, effective, and sustainable coastal management policies. The overarching research question is: what are the awareness and perceptions of coastal residents of the functions of and the relationships between natural, environmental features[10] and engineered infrastructure in mitigating coastal hazards and the impact from coastal hazards? Thus, this research has the following three objectives:

- Explore coastal residents' **awareness** of natural and engineered infrastructure in mitigating coastal hazards.
- Assess coastal residents' **perceptions** of the role of and relationship between natural and engineered infrastructure in coastal hazard mitigation.
- Uncover coastal residents' **preferences** for the use of natural and engineered mitigation infrastructures in their communities.

The three objectives are interrelated centering on the second objective. The first objective provides the necessary background for achieving the second objective. The third objective is the natural extension of the second objective, representing the ultimate goal of the second objective. The research objectives are met by analyzing data from semi-structured interviews with residents in two coastal communities in New Jersey.

[10] The focus of this study is existing mitigation infrastructure including natural, environmental features that comprise natural infrastructure. This investigation does not include the perceptions of nature-based or green infrastructure namely because those types of infrastructure do not currently exist in the two study areas.

CHAPTER 2

LITERATURE REVIEW

Recent federal policies and programs in the United States recognize the importance of integrating both engineered and natural infrastructure in coastal risk mitigation, however implementation at the local level has not been realized in most coastal regions. The integration of both types of mitigation infrastructures must be coordinated at the local level and public support is needed. Coastal hazard mitigation strategies are typically developed and informed by scientists, engineers, and government officials' knowledge and existing policies, not through input by the local public in coastal communities. The role of the public in the governance process is often limited to raising concerns over coastal hazards and accepting mitigation strategies after they have been developed. The lack of public engagement throughout the decision-making process discounts local knowledge and the importance of public perceptions. Local community perceptions of hazards, risk, and mitigation strategies influences how they respond to proposed strategies.

There is limited knowledge perceptions of coastal hazard mitigation infrastructures in at-risk communities. Analysis of public responses to proposed mitigation solutions often only anecdotally report on perceptions. There is limited knowledge of how the public perceives the functions of and relationship between engineered and natural infrastructures in affording mitigation of coastal hazards. Existing literature does not present an understanding of how coastal residents think about both engineered and natural mitigation infrastructures. To better inform decision makers and gain support for integrated coastal mitigation strategies by the public, local perceptions of natural and engineered infrastructures' function in mitigating coastal risk should be assessed.

2.1 Coastal Hazard Mitigation Strategies: Mitigation Infrastructure

The traditional structural approach to coastal hazard mitigation is engineered infrastructure and hardening of shorelines to protect development and mitigate deteriorating conditions such as eroding shorelines. The engineered strategies to mitigate coastal hazards and the impact of coastal hazards is the design and construction of structures such as levees, storm surge barrier gates, seawalls, revetments, groins, and nearshore breakwaters to mitigate erosion and flooding (Arkema et al., 2013; NJDEP, 1981; Spalding, McIvor, et al., 2014). Levees are onshore structures that are designed to protect low-lying areas from flooding (USACE, 2013a). Storm surge barriers are commonly used in levees systems to prevent storm surges from migrating up inland water ways. Seawalls are built parallel to the shoreline to barricade the people and property behind from storm and wave surge. Revetments (usually parallel to shoreline) and groins (usually perpendicular to the shoreline) are structures designed to protect shorelines from erosion. Detached breakwaters are nearshore structures built parallel to the shoreline to reduce wave height, and thus maintain long- and cross-shore sediment transport and mitigate beach erosion. A compilation of these structures makes up the engineered infrastructure in coastal regions for coastal hazard mitigation.

Natural infrastructure is a compilation of natural features created through physical, biological, geologic, and chemical processes (USACE, 2013a). Natural infrastructure includes wetlands, forests, dunes, and water bodies in coastal systems and provides a wide array of benefits to a coastal community (EPA, 2012). Natural infrastructure mitigates many coastal hazards, reducing risk to coastal communities, and also provides ecological and social benefits. Thereby, natural infrastructure both enhances the resilience of coastal areas and may enhance the quality of life of coastal residents. One example of natural infrastructure is coastal wetlands, which function as self-maintaining and adapting horizontal levees that mitigate coastal hazards through wave and flood attenuation, shoreline and sediment stabilization, and wind buffering. Coastal wetlands also provide a suite of other benefits such as recreation, water quality improvement, habitat support, and carbon dioxide sequestration (Barbier, 2013; Costanza et al., 2008; Gedan et al., 2011; Shepard et al., 2011). Research models suggest that existing natural infrastructure protects sixty-seven percent of the U.S. coastline from coastal hazards and risk from coastal hazards increases in two-thirds of the coastline if not protected by natural infrastructure (Arkema et al., 2013).

By evaluating the numerous variables affecting the effectiveness of coastal mitigation approaches, researchers have been able to conclude that the integration of natural infrastructure as part of hazard mitigation strategy may be most cost effective for certain coastal areas[11]. Temmerman, et al. (2013) classified coastal areas according to the potential and the limitations of using conventional (engineered) infrastructure and taking an ecosystem-based approach by comparing exposure to coastal floods,. Variables included sediment accumulation, storm surge attenuation, long-term sustainability, recreation potential, costs and benefits, existing experience and implementation as well as

[11] The beneficial use of natural infrastructure for the purpose of hazard mitigation is dependent on the conditions of the coast as well as how it can be integrated with and its relationship to existing or proposed engineered mitigation infrastructure.

public acceptance. The researchers found that for cities closer to the mouth of estuaries and water bodies, a combination of ecosystem-based approaches and engineered defenses may be best. In areas where there is low elevation and high frequency and duration of tidal inundation, the growth of marsh vegetation might not be successful and tidal inundation might best be reduced with engineered structures.

Figure 2.1 Examples of natural and engineered infrastructure.
Source: Sutton-Grier, et al. (2015): Photo Credits: NOAA for all images except dunes (credit: American Green), sea wall (credit: University of Hawaii Sea Grant), and levee (credit: J. Lehto, NOAA))

Gittman et al. (2014) evaluated the performance of alternative shoreline protections after Hurricane Irene (2007) in three North Carolina locations by classifying the resultant damage after the storm and quantifying shoreline erosion before and after the storm. The protection alternatives evaluated included engineered infrastructure, in the form of bulkheads and riprap revetments, and natural infrastructure, in the form of coastal marshes with and without sills[12]. In the areas where bulkheads surveyed were damaged as a result

[12] Sills are human-placed material on the seaward side of a marsh to prevent erosion.

of the storm there was no damage to other shoreline protection measures and no effect on the elevation of the marshes whether there were sills or not. The impact of Hurricane Irene on marsh vegetation was temporary. Marshes, both with and without sills, provided erosion protection during both Hurricanes Irene and Isabel (2003). Seventy-five percent of the sampled bulkheads in the northern end of the study areas were damaged as a result of Hurricane Irene. The damage to bulkheads was location specific due to the impacts of the storm events (greater storm surge, longer period of sustained winds, wave exposure), geomorphological conditions. It was also influenced by the pre-hurricane condition of the bulkhead. The researchers concluded that marshes are more durable and may protect shorelines from erosion better than bulkheads in Category 1 storms. Eyewitness observations after storms have also indicated that engineered infrastructure provides less protection than hydraulic models predict (Smith et al., 2012). Engineered infrastructure not only provide less coastal hazard mitigation than predicted by engineers and decision makers but often increase the vulnerability of communities in flood plains and coastal hazard areas by displacing flood waters (Colten et al., 2009; Santha et al., 2014; Smith et al., 2012). Together, these research findings indicate that natural infrastructure should be considered as part of a regional strategy for coastal hazard mitigation.

Another argument made by experts for the utilization of natural infrastructure in hazard mitigation is the increased costs of installing and maintaining engineered infrastructure given increasing coastal hazards. Conventional coastal hazard mitigation strategies utilizing engineered infrastructure are increasingly being challenged not only by the increase of the intensity and frequency of storms as a result of climate change, but also by flooding compounded by sea level rise, land subsidence, and the reduction in sediment supply. Thus the costs for installation, maintenance, and adapting these structures to increasing hazard conditions are increasing (Temmerman et al., 2013). Existing coastal mitigation strategies solely utilizing engineered infrastructure cannot ensure the resilience or sustainability of coastal communities in the face of these growing threats (Liquete et al., 2013). Engineered mitigation infrastructure is a form of resistance to coastal hazards and has made little use of the resilient and adaptive features of natural infrastructure (van Slobbe et al., 2013). Ironically, engineered structures are being increasing relied on due to the increase in coastal hazards and the increasing numbers of people, development, and assets in coastal areas (Spalding, McIvor, et al., 2014). As the frequency of coastal hazards increase, the value of natural infrastructure will increase as well (Costanza et al., 2008).

Further complicating effective coastal hazard mitigation is the fact that engineered infrastructure designed without consideration of nearby natural features or without incorporation of natural infrastructure threatens existing coastal ecosystems through direct and indirect negative impact to their functioning. This reduces their ability to provide essential ecosystem services, including mitigating coastal hazards. Human modification of the coastal zone, such as the construction of engineered infrastructure, decreases sediment supply, alters hydrologic functioning, and increases land subsidence further amplifying coastal hazards and thereby risk (Shepard et al., 2011). Land-based changes and built infrastructure have reduced the extent and health of coastal ecosystems through fragmentation, loss and damage, as well as impeding coastal ecosystems' necessary migration inland with sea level rise (coastal squeeze) (Spalding, Ruffo, et al., 2014). Barbier (2013) provides evidence that engineered infrastructure for coastal hazard defense in both Europe and the United States has accelerated wetland loss. This is because engineered infrastructure cuts wetlands off from needed water inundation (Temmerman et al., 2013). More than half of the salt marshes in the United States have been lost to direct and indirect impacts from built infrastructure and land use decisions (Shepard et al., 2011). The accelerated loss of natural infrastructure such as coastal wetlands increases the vulnerability of people and property in coastal areas (Barbier et al., 2013).

Strategies have been developed by scientists and engineers to address both the resilience of coastal areas and the long-term sustainability of mitigation structures by integrating the functions of both natural and engineered infrastructure. "Managed realignment," the deliberate reconnection of coastal lands to the tidal system through the opening of seawalls and filling of engineered drainage channels and resulting natural regeneration of salt marshes, has been utilized in Europe and North America (Spalding, McIvor, et al., 2014). Managed realignment is a means to allow coastal ecosystems to move and adapt to changing environmental and hydro-meteorological conditions, such as increasing storm surge and sea level. One type of managed realignment is using natural infrastructure to protect engineered infrastructure (Sutton-Grier et al., 2015). These integrative strategies have been implemented through government support in some countries. For example, "Building with Nature" is an innovation program used in the Netherlands and supported by a number of government organizations that seeks to address flooding by integrating natural and environmental processes with engineered infrastructure (van Slobbe et al., 2013). "Engineering with Nature" is a USACE initiative where there is an "intentional alignment of natural and engineered processes to deliver economic, environmental, and social benefits" (Banks, 2014). These integrated strategies for coastal hazard mitigation can be considered hybrid approaches (Sutton-Grier et al., 2015) or "greening flood protection": the inclusion of natural and environmental processes to optimize flood mitigation strategies (Janssen et al., 2014).

Despite recent interest on the part of the federal government in the United States in hybrid approaches and integrating the functions of both engineered and natural infrastructure, structural hazard mitigation strategies have traditionally relied on engineered infrastructure such as sea walls and bulkheads, especially in areas with substantial assets at risk (Spalding, Ruffo, et al., 2014). The more recent interest in utilizing natural infrastructure and hybrid approaches comes from scientists and through federal and state agencies not particularly from local political demands. This may be because the functions of natural infrastructure are not as well understood, or engineered infrastructure is perceived by local decision makers to work better. For example, Gittman et al. (2014) claim that most coastal property owners choose hard (engineered) structures, such as bulkheads, to protect their coastal property from erosion as a result of their perceptions that these structures will function better over the long term. Performance and cost efficiency seem to be among the key factors in decisions on structural hazard mitigation strategies.

2.2 Hazard Mitigation Governance: Coastal Policies and Local Implementation

Given the risks to coastal communities from increasingly frequent coastal hazards and major federal and state investments and interest in the coast, coastal management is a priority for federal and state governments. Various government agencies at the federal and state level are involved in coastal management. Many of these are key actors involved in decisions associated with structural mitigation strategies. Each agency has a suite of policies and programs based on its own mission related to coastal risk mitigation. In "home rule" states like New Jersey, local governments play a role in the decisions through their emergency management, engineering, land use, and planning authority.

The U.S. Army Corps of Engineers (USACE), state agencies, and local engineering departments have the responsibility to design and build engineering structures to minimize economic damages to property. Federal, state, and local emergency management programs such as the Federal Emergency Management (FEMA), and state and local Offices of Emergency Management (OEM) focus on mitigating disasters from coastal hazards through evacuation, emergency response, and preparedness. Environmental agencies such as Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), and the wildlife programs of the Department of Interior (DOI) pursue coastal projects for the protection of human and ecosystem health that often include ecosystem restoration or protection of natural resources. And, state and local governments are responsible for land use decisions that affect the implementation of structural measures for coastal hazard mitigation.

Federal programs and policies are developed, designed, and adopted for explicit purposes to support the missions of the agencies that carry them out. Programs within the DOI aim to "assess, restore, enhance, or create wetlands, beaches, and other natural systems to help better protect communities and to mitigate the impacts of future storms" (NFWF, 2015), as well as to "to increase the resilience and capacity of coastal habitat and infrastructure to withstand storms and reduce the amount of damage caused by such storms" (USFWS, 2014). USACE's mission is to protect coastal communities' economic functioning through navigation assurance and flood protection through reliance on engineered infrastructure and to mitigate any resultant ecosystem damages (USACE, 2014b). NOAA focuses on protection of the natural resources of the ocean, on coastal adaptation to climate change and sea level rise, as well as working with coastal communities to provide support to develop more robust mitigation and land-use plans (NOAA, 2015). EPA's programs such as the National Estuary Program have the goal of reducing environmental damages and protecting human health (USEPA, 2014). For these federal projects to fulfill their ultimate goals of protecting coastal communities and the environment from coastal hazards these projects must be integrated requiring coordination among the government programs and with the local communities that the projects affect. This entails that project managers discuss their projects with counterparts at other federal agencies and within the communities where the projects are proposed. Although various hazard mitigation efforts are pursued through federal, state and local programs and mitigation projects implemented, those projects have been fragmented and many of the efforts have not provided a comprehensive strategic framework for project integration (Penning-Rowsell et al., 2014; GAO, 2007; GAO, 2014). Policies are developed from economic and ecological standpoints, especially in coastal areas, and often they are not integrated and in many instances conflict (Janssen et al., 2014).

While there has been a heavy reliance on engineered infrastructure to mitigate coastal hazards, NOAA and USACE have jointly called for a systems approach for building coastal resilience by specifically recognizing that natural systems are inextricably linked with and contribute to the resiliency of physical infrastructure, community wellbeing, and coastal economies (NOAA, 2013). The relationship between natural and engineered infrastructure is recognized by the USACE as being an important variable in determining coastal vulnerability, reliability, risk, and resilience (USACE, 2013a). The failure of one component or process of mitigation infrastructure may affect the probability of failure of other components or processes. The lack of coordination between hazard mitigation policies and with the at-risk coastal communities for the integration of engineered and natural infrastructure strategies may reduce the resilience of coastal communities to increasing coastal hazards.

The Federal Government recognizes that hazard mitigation can benefit from more consistent integration of natural infrastructure with engineered infrastructure and other mitigation decisions (NOAA, 2013). Under recent Federal Executive Action (EO 11988, January 30, 2015) guiding the revision of the Federal Flood Risk Management Standard (FFRMS) (FEMA, 2015), all Federal actions in floodplains are encouraged to use natural systems, ecosystem processes, and nature-based approaches (FEMA, January 28, 2015). Despite these policy statements, hazard mitigation provided by natural infrastructure is not sufficiently accounted for in coastal planning and engineering practice (Spalding, McIvor, et al., 2014). This could be due to insufficient research and resulting communication evaluating the role of natural infrastructure in coastal risk mitigation compared to that of engineered infrastructure (Arkema et al., 2013; Sutton-Grier et al., 2015) or less public awareness of the role natural infrastructure plays in affording hazard mitigation resulting in less public demand.

The USACE recognizes that it has traditionally focused on engineered structures for risk mitigation and has not taken the opportunity to improve the resilience of the coastal community and utilize natural infrastructure for hazard mitigation (Schultz et al., 2012). Although the USACE is required to mitigate loss of natural infrastructure, such as coastal wetlands, as well as to minimize environmental impacts, the agency cannot be expected to consider other environmental benefits in their designs, since their benefit-cost analyses do not include any explicit environmental variables. USACE's recent Engineering with Nature Initiative and North Atlantic Coast Comprehensive Study indicates that the agency is beginning to consider natural infrastructure to meet their mission in mitigating coastal hazards (Banks, 2014; USACE, 2015). The USACE's implementation of its Engineering with Nature Initiative has encountered obstacles, including agency culture and resistance to change as well as conflicting goals. The USACE has identified means to overcome these barriers that include better communication and collaboration between all governance actors and addressing stakeholder uncertainty about mitigation options in order to gain more support for implementation of comprehensive, integrated strategies. Coastal hazard mitigation decisions should consider multiple stakeholder[13] preferences, especially the preferences of the public from coastal communities as they are an underutilized but important governance actor.

2.3 Importance of Local Perceptions in Hazard Mitigation Governance

Coastal hazard mitigation is a complex phenomenon, and so overly simplistic policies and actions can have unintended consequences. Comprehensive policies and strategies are difficult to develop because of the diversity and breadth of actors involved in hazard mitigation governance. There are differences in stakeholder interests and preference and

13 Stakeholders in coastal risk governance are interest groups, experts, decision makers, and socio-economic users of coastal areas. In most research studies they are political-institutional (government officials, environmental interests, public works, emergency management, planning officials), socioeconomic (trade associations, businesses) and experts (academics) (Frazier et al., 2010; Kane et al., 2014; Roca et al., 2012; Touili et al., 2014). Many studies consider these stakeholder groups to be the "public". There is a difference between the general public (includes those that live outside coastal areas) and local public. In this research study the public investigated are residents in coastal communities at-risk.

the challenge is to balance the economic and social interests of all stakeholders, especially the public from coastal communities. Conflicts arise in the governance process not only as a result of differing perceptions of risk (Lubken et al., 2011) posed by coastal hazards but also from differing perceptions of the efficacy of hazard mitigation strategies (Prati et al., 2016). Once the varying perspectives and perceptions held by the public are understood, communication can be improved, education efforts can be directed and public responses to proposed strategies can be anticipated, improving the governance process.

The public's perceptions and awareness of hazards and mitigation strategies can be a driver of policy change. More integrative and innovative strategies for hazard mitigation may be pursued if there is a public demand and sensibility toward the use of natural infrastructure in mitigating coastal hazards. Given the federal and state interest in and wealth of policies around coastal management, coastal management decisions are not as sensitive to local demands as other policy decisions. A challenge to the implementation of integrative coastal management strategies may be public support. Slovic (1987) claimed that well-intended mitigation policies may be rendered ineffective if decision makers do not appreciate the public's perceptions of risk and mitigation strategies.

Given the fact that, to date, coastal hazard mitigation strategies have relied heavily on engineered infrastructure, the utilization of both engineered and natural infrastructure as an integrative strategy for the mitigation of coastal hazards can be innovative. The factors that influence support for such innovative, integrative strategies include the perceived benefits, role of innovators, local community engagement and buy-in, and social norms (Kochnower et al., 2015). One problem is that public institutions are often reactive, not proactive, and have little incentive for innovation: innovation often depends on individuals and is not commonly embedded in the governance process (Penning-Rowsell et al., 2014). Innovation can infiltrate into the governance process through more public engagement and knowledge sharing. The willingness of stakeholders to adopt innovations in coastal hazard mitigation increases with the level of participation in the governance process (Karrasch et al., 2014).

Public participation is necessary to reduce conflict within the risk governance process and to legitimize decisions. Public engagement is limited in the governance process: public input into policies usually occurs at the end of the decision making process, after options have been developed. This lack of early and consistent public engagement leads to public distrust in the governance process (Roca et al., 2011; Santha et al., 2014; Schmidt et al., 2014). The lack of public engagement and appreciation of public perceptions in the governance process may lead to automatic public opposition to innovative strategies when presented, leading to unsuccessful implementation of those strategies (Spalding, McIvor, et al., 2014; Temmerman et al., 2013). Management decisions carried out in isolated ways lead to public suspicion, distrust, and higher likelihood of rejection of mitigation proposals (Roca et al., 2011). Trust by local stakeholders and the public can be enhanced by local stakeholders being included and listened to throughout the governance process (O'Sullivan et al., 2012; Roca et al., 2011).

To ensure public participation, it is necessary to understand people's knowledge and perceptions of specific issues (Koutrakis et al., 2011). The public will best be able to provide support and input into mitigation strategies if it is are informed and aware of the mitigation strategies that exist or are proposed (Myatt et al., 2003). The public expresses dissatisfaction with coastal decisions when it is not knowledgeable about mitigation schemes (Koutrakis et al., 2011). Also, the public will not engage in discussions over mitigation strategies if it perceive the strategies to be highly technically complex (Godschalk et al., 2003). Information sharing and communication may reduce this barrier to public engagement. Godschalk et al. (2003) found through case studies of hazard mitigation planning in four Florida and Washington State communities that communication, information sharing, and receptivity of public engagement by government officials led to stronger and more innovative policies. They found that knowledge sharing helps reduce the perceived barrier to discussing technical and scientific mitigation strategies by using a more common language.

The knowledge arrangements within the governance process are the dynamic, interdependent constellation of the knowledge base of governance actors and their discourses. The knowledge arrangements change over the stages of policy development[14] (Janssen et al., 2014). In a case study of a large flood mitigation project in the Netherlands, Janssen et al. found that knowledge arrangements are integrated in most stages of policy development, but during the latter part of the mitigation strategy assessment phase and into the preferred design alternative planning stage of decision making, knowledge arrangements between the flood protection and nature protection were separated. Janssen et al.'s research suggests that knowledge development should take place as closely to the policy development process and include extensive interaction among stakeholders.

Coastal hazard mitigation governance requires the involvement of multiple levels of government and will be enhanced by the integration of scientific and engineering knowledge with consideration of the perspective of the public in areas experiencing coastal

[14] The three stages of policy development are design, assessment, and decision-making (Janssen et al., 2014)

hazards. The process for gaining public support for proposed mitigation strategies will be made easier if those strategies are developed using knowledge that is credible, salient, legitimate, accepted by all governance actors and relevant in the context of its application (Seijger et al., 2016). This socially-robust knowledge is produced by integrating the perspectives and interests of all stakeholders. There is evidence that many mitigation decisions are not made using socially-robust knowledge. Often it is exclusively the knowledge and perspective of scientists, engineers and policy makers that inform decisions.

Eden (1996) argues that for successful implementation of environmental policy, in general, knowledge should extend beyond scientific expertise to an "active knowledge" that includes the ways in which the members of the public connect their experience to the natural environment. Local awareness and knowledge of hazard mitigation infrastructure can complement scientific knowledge and help produce more comprehensive policy decisions. Collective new knowledge can be produced by sharing experiences. Communities at risk can provide useful knowledge to risk governance and the decision making process based on their first-hand experience with coastal hazards (Cadag et al., 2012). Local knowledge is essential to effective environmental decision making, especially in the case of hazard mitigation, because of communities' familiarity with its surroundings and its experience with and perceptions of mitigation infrastructure, previous decisions, and the effects thereof.

Local knowledge and preferences are often not incorporated into the governance process of mitigation decisions. Santha et al. (2014), in exploring local fishing communities' empirical and paradigmatic knowledge[15] of coastal hazards and risk, found contradictions between local knowledge and mitigation decisions and that local knowledge is not factored into mitigation decisions. The perception of one local fishworker from Santha et al.'s study is that engineering decisions have negative consequences, engineering knowledge is limited, and decisions should be informed by local knowledge. The perception of this local actor is that his local knowledge has not been valued:

> *"These engineers and contractors think that they know everything under the sun. In reality, they do not know anything. Whatever they do becomes a blunder and it in turn affects our very survival and security. Even after us objecting to the construction of the seawall, they have built it in our village. This has induced coastal erosion and further destruction. They think that they can control nature with their new knowledge and technologies. They do not value our knowledge and understanding of the sea. Our knowledge of the sea, coast and hazards is more reliable and accurate than these engineers and scientists. Nevertheless, they seldom do recognize our knowledge, expertise and needs." (pg. 119: (Santha et al., 2014))*

Local wisdom can be imparted to decision makers and combined with scientific knowledge becoming a form of collective learning. Local knowledge can be demonstrated in a number of ways such as local community members mapping geographic locations of vulnerability (Cadag et al., 2012) and ground-truthing geomorphological conditions compared to scientific data (Bethel et al., 2011). This knowledge sharing can help navigate the complex kinds of information necessary for coastal hazard mitigation by integrating diverse understandings of hazards and broadening the discussion of mitigation strategies (Reyers et al., 2015).

[15] Empirical knowledge refers to experience-based knowledge gained from direct observation and experience of interacting with the natural environment whereas paradigmatic knowledge is associated with the cultural construction of causal relationships, interrelations and the meaning of these relationships within empirical knowledge (Santha et al., 2014)

Knowledge sharing and early, consistent communication is key to improving the governance process, and to better ensure that decisions will be supported by the communities. Discourse among governance actors is often difficult because of differing perception and knowledge[16]: there is a disconnection between the language used by the scientific community and that understood by the public that can be overcome by all actors having an understanding of each other's' perceptions and co-producing knowledge about conditions and strategies (O'Sullivan et al., 2012). A shared discourse among scientists, government officials, local stakeholder groups, and the public can ensure clearer communication of the benefits of innovative and integrative strategies, such as incorporating natural infrastructure into coastal hazard mitigation (Temmerman et al., 2013). Effective communication in the governance process can result from all governance actors having a better understanding of the varying perceptions and knowledge of each other.

An important characteristic of resilience is the capacity of communities to adjust and prepare for hazards using available resources and to apply of knowledge from experience with the outcomes of previous decisions (Lopez-Marrero, 2010; Russell et al., 2012). Learning from past hazard events and the use of accumulated social memory is essential for resilience. A community may be made more resilient by having community members and decision makers that reflect on the causes of their vulnerabilities and mobilizing resources that avert threats based on experience (Goldstein, 2008). Community

[16] Where people get their information of hazards and risk and build their knowledge of coastal management options is important because it will influence their perception and attitudes towards solutions. Most technical information is provided by scientists. Most learning is done through discussion among relatives or through personal investigation resulting from curiosity, the government and local institutions are the least source of public awareness of coastal risk and mitigation strategies (Santos et al., 2013). Information on innovative mitigation schemes, such as managed realignment, usually comes from the media (Myatt et al., 2003).

resilience is challenged when hazard mitigation strategies neglect reflection on previous decisions and discount local knowledge (Colten et al., 2009). More diverse participation in the governance process can ensure that the experience with past decisions might be learned from. By incorporating the lessons learned from a communities' experience into decisions on coastal hazard mitigation, governance can be integrative, adaptive, and inclusionary assuring more resilient communities (Renn et al., 2011). A community's collective social memory[17] of past decisions and their effects can aid in producing more effective mitigation decisions and enhance decision making when drawn on (Adger et al., 2005). This is especially true when the knowledge of local communities, informed by community members' experience with hazards and their impacts, is incorporated into the evaluation of hazard mitigation strategies. The public typically values having choices and it is important to the governance process that the members of the public understand those options. Thus, stakeholder experience with hazards and mitigation infrastructure should help inform hazard mitigation practice (Penning-Rowsell et al., 2014).

2.3.1 What Comprises Perception

Perception is influenced by values, knowledge, and cultural factors and affects attitudes and resulting preferences for mitigation strategies. Public interest in hazard mitigation strategies is influenced by an individual's perception of risk from those hazards and the perceived personal benefit from mitigation options. Perception of risk, the attitudes and judgments of, and preferences for hazard mitigation strategies have social, political, economic, and cultural contexts (Renn et al., 2011). It is within these contexts that

[17] This collective memory made up of the diversity of individual and institutions drawing on their knowledge, values, and worldviews (Adger et al., 2005).

individual values and collective norms are made evident. Perception of the benefits of hazard mitigation strategies is informed by experience and knowledge about hazard events and previous decisions (Boyer-Villemaire et al., 2014; Frazier et al., 2010). For example, public perceptions of the benefits provided by natural infrastructure is more likely informed from heuristics than objective information provided by other stakeholders (Kochnower et al., 2015).

Having experience with coastal hazards and being personally affected increases the salience of those hazards. Therefore duration of living within an at-risk community is one contributor to how one perceives coastal hazards (Boyer-Villemaire et al., 2014). Feeling a sense of personal risk (individually or to one's assets) and concerns about the effects of a hazard on the economic functioning of a community significantly affect the public's perceptions of hazard mitigation strategies and interest in mitigation policy (Greenberg et al., 2014; Schmidt et al., 2014).

Cultural factors, including social norms, values, and traditions, influence perceptions as well (Kane et al., 2014; Touili et al., 2014). Emotional connections to place and associated values can also influence perceptions of mitigation strategies: Kochnower et al. (2015) found that public support for the use of natural infrastructure is influenced by the desire to return one's area to a more natural state. Perceived benefit to one's self or group's interests will also influence preferences and attitude (Frazier et al., 2010; Mustelin et al., 2010). Governance actors will prefer mitigation strategies based on their perception of the protection provided to them. Mustelin et al. (2010) found that community members employed in the tourist industry prefer sea walls to protect the assets important to their livelihood, such as hotels, whereas fisherman prefer vegetation to protect the functioning of the coastal ecosystem which they depend for their livelihood. Godschalk et al. (2003) found that one factor influencing the public's disinterest in discussions over hazard mitigation strategies was the failure of the strategies to address their site-specific concerns such as zoning, land use or planning issues.

Attitudes toward coastal hazard mitigation are also based on problem awareness including perception of urgency, being able to understand the complexity of coastal hazards, as well as values, motivation and the ability to take action (Loomis et al., 2014). Participatory decision making within the governance process cannot be achieved without a functional awareness of risk. This functional awareness includes not only an understanding of coastal hazards and an appreciation of the dynamics and interactions within the coastal zone, but having a perspective toward hazard mitigation strategies (Boyer-Villemaire et al., 2014).

The salience of coastal hazards and risk enhances problem awareness and urgency for evaluating options. Most coastal communities can understand coastal hazards, and this understanding along with concern about risk can influence perception of mitigation strategies (Boyer-Villemaire et al., 2014; Cadag et al., 2012; Koutrakis et al., 2011; Schmidt et al., 2014). Recent disasters enhance public awareness and promote a focus on mitigation strategies, but once the salience of the risk decreases there is little effort to evaluate the effectiveness and functioning of existing mitigation strategies (Bijker, 2007). Strong risk perception and citizen interest is necessary for effective public engagement (Schmidt et al., 2014). Being aware of risk leads community members to appreciate discussion of hazard mitigation strategies, even though attitudes and preferences based on perceptions will very among stakeholders (Frazier et al., 2010; Stevens et al., 2010).

2.4 Perceptions of Coastal Hazards and Risk

Conflict over decisions for coastal hazard mitigation strategies do not only arise from stakeholders' differing values and interests and perceptions of the efficacy of those strategies. They also stem from stakeholders' perceptions of the hazard and associated risk (Prati et al., 2016). Prati et al. (2016) found that those stakeholders who opposed beach nourishment as a strategy to deal with shoreline erosion either denied erosion was a problem or viewed the intervention as detrimental or unnatural. Perceptions of both coastal hazards and the risk posed by coastal hazards is a major component of how individuals react to coastal hazard mitigation strategies. The length of public memory of coastal hazard events, and thus the consciousness of the risks posed by coastal hazards, affect support for policy decisions about mitigation and the likelihood that members of the public will call for previous hazard mitigation investments to be re-evaluated.

Perceptions of risk includes awareness of, concern about, and preparedness to respond and adapt to hazards (O'Sullivan et al., 2012). The main factors that influence an individual's perception of coastal hazards are the local characteristics, such as geomorphology, cultural experience, education level, and length of time in the community (Boyer-Villemaire et al., 2014). Experience with the effects of coastal hazards, such as damage to property, will affect perception of risk.

The perceived extent of coastal risk is often low where hazard events have been rare in the immediate past (Penning-Rowsell et al., 2014), therefore it is important to investigate perceptions of coastal hazard mitigation strategies in locations were coastal hazards are salient. Risk perception can be lowered or inaccurate if there is a lack of understanding of the hazards faced and/ or there is heavy reliance or trust in existing hazard mitigation strategies, such as warning systems or engineered mitigation infrastructure, by promoting a false sense of security (Couling, 2014; Lopez-Marrero, 2010; Mustelin et al., 2010). Perception of risk is often influenced by perception of the effectiveness of existing hazard mitigation strategies. Tania Lopez-Marrero (2010) examined the public's experience of changing conditions brought by flood hazard events in two flood-prone communities in Puerto Rico. She investigated residents' perceptions of the effectiveness of strategies for coastal hazard protection, flood risk, and barriers to effective implementation. Lopez-Marrero found that one of the barriers to the public's support of mitigation strategies was lowered perception of risk due to experience with decreasing trends in precipitation and flood events as well as personal adjustments to flood risk perceived as sufficient. Existing engineered strategies including structures in the form of dikes and river channel modifications also appear to reduce the perceptions of risk from flooding. This low risk perception may limit exploration of innovative mitigation strategies, including the use of natural infrastructure. Therefore, it might be argued that a higher salience of coastal hazards among the public and the associated risks may lead to consideration of more comprehensive mitigation strategies, including integrating natural infrastructure.

Many studies have presented stakeholder's perceptions of hazards and their perceptions of what increases the probability of negative consequences from hazards (Cadag et al., 2012; Kane et al., 2014; Lubken et al., 2011; Parvin et al., 2008; Santha et al., 2014; Tunstall, 2000). Stakeholder groups have identified the unforeseen impact of human activities, whether engineered flood protection infrastructure or interference with natural systems, as the main cause of damages from flood hazards (Kane et al., 2014).

Stakeholders in coastal areas have also identified ill-designed policies, mostly through administrative segmentation, poor land use planning, inappropriate engineered infrastructure and lack of funding, as evidence of increased risk. Research findings suggest that it is possible for the public from at-risk communities also to have a perception of enhanced risk resulting from governance decisions.

In their research with fishing communities in India, Santha et al. (2014) learned these local communities perceive "perils of the coast" to be the risk and threats imposed by engineered interventions. The participants in the study reported observing that many of the engineered interventions have exacerbated coastal risk: that policy decisions have been more threatening to their livelihoods than direct threat from natural hazards and often the policy outcomes are hidden, uncertain, and not widely understood. Participants attributed the increase risk of coastal flooding and erosion to engineered mitigation infrastructure: that engineered structures such as sea walls, groins and breakwaters have aggravated the intensity of the impact of the hazards. In 16 of the 20 villages surveyed, engineered structures were considered the major cause of the coastal risk.

2.5 Public Perceptions of Hazard Mitigation Infrastructure

There is an inconsistency among stakeholder groups' perceptions and knowledge of both coastal problems and mitigation strategies (Roca et al., 2012). Stakeholder preferences for mitigation infrastructure is fragmented based on level of experience with coastline changes and other locational characteristics and cultural values (Boyer-Villemaire et al., 2014). Frazier et al. (2010) found that even with common agreement to increase community resilience to coastal hazards, there are sector-specific preferences on how to do so. In their case study of Sarasota, Florida, the majority of stakeholder sectors were focused on non-structural risk mitigation strategies such as evacuation planning or relocating buildings out of hazard zones. The researchers found that only an environmental interest group preferred banning shoreline hardening and encroachment on coastal wetlands, encouraged retreat, and supported reestablishment of natural habitats. The public's preference for mitigation strategies was not investigated in Frazier et al.'s study. Uncovering the public's perception of mitigation strategies, especially the use of engineered and natural infrastructure, will complement findings regarding sector-specific stakeholder preferences.

A number of researchers have found that differing stakeholder preferences for engineered or natural infrastructure is due to perceived benefits, not just the functions of mitigating coastal hazards. The perception of mitigation infrastructure is often associated with the benefits that the structures provide to socioeconomic activities. Roca and Villares (2012), in studying sector-specific stakeholders' preferences for future mitigation strategies in the Spanish coast, including engineered infrastructure and managed realignment (restoration of dunes and wetlands), found that engineered infrastructure is preferred by a majority of stakeholders for its benefit to socioeconomic activities such as fishing and farming. Since residents were not interviewed for Roca and Villares's study, it is not known if their preference of mitigation strategies would be a result of the same perceived benefits. Khew et al. (2015) did investigate public perceptions of engineered infrastructure in the Chilean coast and found that support for such engineered structures, in the form of sea walls and promenades, is associated with the provision of economic services such as the promotion of tourism and fishing not for substantial reduction of impacts from storms. Although the local communities in Khew et al.'s study did not perceive the engineered mitigation structures to substantially reduce impact from storms, the public believed the structures raise awareness[18] of tsunami hazard since they display tsunami warning signs and house a memorial to tsunami victims. The use of natural infrastructure is commonly valued by stakeholders for the sake of preserving of nature and the socio-economic benefits natures provides such as tourism in coastal areas (Roca et al., 2011), aesthetic quality of the landscape providing improvement to quality of life (Curado et al., 2014; Karrasch et al., 2014) and habitat (Curado et al., 2014) but not for hazard mitigation. This research suggests that investigation of local residents' perceptions of coastal hazard mitigation infrastructure should include inquiry of perceived benefits.

Preference for coastal hazard mitigation strategies is related to the level of stakeholders' perceptions of the benefits afforded as well as their functional awareness[19] of coastal hazards and associated risk. Although most communities value coastal management, preventative solutions, and nonstructural strategies preferences for mitigation strategies vary with functional awareness (Boyer-Villemaire et al., 2014). Research shows that preference for mitigation strategies differ with degree of experience with hazards and perception of risk. Boyer-Villemaire et al. (2014) discovered that communities with a lower perception of dread and uncertainty about coastal hazards and limited knowledge about mitigation strategies (low functional awareness) favor engineered structures, while those that have a weak perception of dread and less experience with

[18] Raising awareness of risk may lead to personal measures to protect oneself, family and property from hazards.

[19] Boyer-Villemaire et al. (2014) quantified citizens' perception using three themes of "functional awareness" of coastal hazards: dreadfulness, uncertainty and attitude toward solutions. Indicators of dreadfulness include the concordance of participants' perception of hazard dynamics with that of geoscience data as well as experience. Indicators of uncertainty include understanding of the variability and dynamics of the coastal system and associated hazards as well as the interactions between human activity and coastal hazards. Attitude toward solutions is preference of mitigation strategies.

hazards have a "blind confidence" in all mitigation strategies. Only those communities with an accurate risk perception, both of dread and uncertainty (high functional awareness), including an awareness of the negative consequence of hard structures, disapprove of the use of engineered infrastructure. Boyer-Villemaire et al. investigated public preference for a whole suite of non-structural and structural mitigation strategies and found low commonality among the community in preferred strategies. Their discovery of the connection between a community's high functional awareness of risk and less common agreement of the mitigation strategies might be attributed to the breadth of options they explored with the community. Their research indicates that in communities where risk is salient and hazards understood, there might not be easily identifable stakeholder consensus on what mitigation strategies should be undertaken, further emphasizing that sharing all governance actors' perception and knowledge will enhance the decision making process.

Preference for mitigation strategies is also influenced by what currently exists, or has been done, in a community and stakeholder awareness of those strategies. Koutrakis et al. (2011) found that in communities where there is a prevalence of natural features, there is also a perception of lowered risk from erosion, and there is less support for use of engineered structures. In areas where the existing engineered flood mitigation strategy is claimed to be understood by stakeholders perception of risk from floods is lower (Tunstall, 2000). Research indicates that there are many variables that will influence local public perception of mitigation infrastructure. Perception of and preference for mitigation infrastructure is influenced by experience with hazards, risk perception, and awareness of mitigation strategies.

Researchers have attributed public uncertainty about the use of strategies that focus on the use of natural systems, such as managed realignment, to the lack of experience or familiarity with those strategies (Roca et al., 2012). In most coastal areas the existing mitigation strategies are hard (engineered) infrastructure or sand re-nourishment. Perception of mitigation strategies will vary according to location and people's experience with hazards and existing risk mitigation infrastructure. Since coastal hazards and associated risk is site-specific, conditioned on many variables not just the existence of mitigation infrastructure, and potential mitigation strategies that are equally diverse, it is important to understand the public's perception at the local level. Likewise, it is important to study public perception of mitigation infrastructure in communities where both structures and features exist.

Although engineered infrastructure has been heavily used in coastal hazard mitigation, some researchers have found that stakeholders have reservations toward engineered mitigation strategies, and some evidence of what stakeholders perceive of the engineered structures' function. Santos et al. (2013) found that almost half of residents they surveyed considered engineered structures to be effective locally, in the short term, by accumulating sand and reducing the energy of the sea, and that more engineered infrastructure might be more effective. Some stakeholders have reservations about the use of engineered infrastructure due to lack of trust in the capacity for proper maintenance of the structures and the belief that this lack of maintenance would enhance risk (Touili et al., 2014). The literature suggests that it is important to investigate perceived drawbacks and problems with mitigation infrastructure.

Equally important to assuring a broader discussion and public engagement in coastal hazard mitigation decisions by including an understanding of local public perception of mitigation infrastructure's functions is having governance actors appreciate the relationship between natural and engineered infrastructure. Scientific knowledge suggests that there are positive and negative feedbacks between engineered and natural infrastructure and that these relationships should be taken into consideration when making decisions on which mitigation strategies to employ. Perceived relationships between engineered infrastructure and natural infrastructure have not been directly investigated with stakeholder groups, nor with the general public. However, researchers have found when investigating preferences for mitigation strategies that stakeholders recognize that engineered structures can have negative impacts (Boyer-Villemaire et al., 2014; Santos et al., 2013; Touili et al., 2014). Touili et al. (2014) found a stakeholder appreciation of the "redistributive effects" of engineered infrastructure: a recognition that while protecting some pre-identified assets engineered infrastructure displaces flood waters elsewhere, and that these redistributive effects are not always taken into account in the design of the engineered structures. Study participants, sector-specific stakeholders (not residents), were distrustful of engineered structures due to their perception that the structures distribute risk spatially. Engineered infrastructure has been recognized by decision makers and the public as working against natural processes (Cooper et al., 2008) and causing adverse effects in neighboring areas (Santos et al., 2013). No study has directly asked stakeholders both how they think these infrastructures work in mitigating coastal hazards or how they think they might affect each other. Existing research findings suggest that through direct inquiry we could identify public perceptions of both engineered and natural infrastructure in coastal hazard mitigation.

The successful implementation of more comprehensive, innovative mitigation policies such as the reliance on more natural infrastructure or the integration of both natural and engineered infrastructure may be achieved if all stakeholders appreciate the function of natural infrastructure and the relationship between mitigation infrastructures. Members of the public from at-risk coastal communities are often overlooked governance actors in studies on public perception. The majority of research on perception of hazard mitigation strategies has mostly been limited to stakeholder groups representing economic sectors, government, or scientists (Cadag et al., 2012; Frazier et al., 2010; Kane et al., 2014; Karrasch et al., 2014; Kochnower et al., 2015; Penning-Rowsell et al., 2014; Roca et al., 2012; Touili et al., 2014). Understanding local residents' perception of the function of and relationship between mitigation infrastructures will bridge a knowledge gap in the hazard mitigation governance process. Research about perceptions of coastal residents has been limited to questions of preference (Boyer-Villemaire et al., 2014; Friesinger et al., 2010; Koutrakis et al., 2011) with very limited findings on how the public perceives the functions of (Curado et al., 2014; Kim et al., 2013; Mustelin et al., 2010) or relationship between (Myatt et al., 2003; Santha et al., 2014) mitigation infrastructures. And no researchers have investigated public preferences for, awareness and perceptions of the functions of and relationship between these infrastructures.

Understanding local residents' perceptions of the role of, relationships between, and preferences for coastal hazard mitigation infrastructure can help identify how comprehensive policies for hazard mitigation might be received by communities that the policies affect. It is important to understand local communities' perceptions in order to achieve a stronger governance process, one that improves communication and through which there is a better anticipation of how the public in communities at risk will respond to proposed mitigation measures.

2.6 Public Awareness of Natural Infrastructure for Hazard Mitigation

The limited use of natural infrastructure for coastal hazard mitigation may be due to the public's incomplete understanding of the functions of natural infrastructure such as coastal wetlands or dunes in reducing hazards (Janssen et al., 2014). Federal agencies recognize that to realize the integration of natural infrastructure into comprehensive mitigation strategies, better public understanding of its role is needed (NOAA, 2013). The public's valuation of natural infrastructure in coastal hazard mitigation is required to support more comprehensive policy (Barbier, 2013).

The literature on coastal hazard mitigation indicates that there is limited knowledge of, or at least support for, protection or enhancement of natural infrastructure for the purpose of reducing coastal hazards or impacts of them. Low public perception of the benefits of natural infrastructure will prove to be a major challenge for comprehensive hazard mitigation policy implementation. The disconnect between coastal hazard mitigation decisions and enhancement of natural infrastructure and limited surveys of public perceptions specific to the role of natural infrastructure calls for research to investigate the public's perception of the functions of natural infrastructure.

Despite a few studies, much of the existing literature about natural infrastructure's role in mitigation presents the knowledge of scientists and utilizes economic methods to value natural infrastructure in hazard mitigation (Barbier, 2013, 2014; Barbier et al., 2013; Costanza et al., 2008). The economic valuation literature for coastal ecosystem services is insufficient to support policy making due to limited geographic data, uneven methodology, and key values not being estimated (Barbier et al., 2013). Economic valuation methods have some potential to raise awareness of the benefits of natural systems, but have limited applicability to influence public perceptions or change individual values (Hein et al., 2006). There is a disconnect among the knowledge of stakeholders, scientific knowledge, and management practices related to ecosystem services such a hazard mitigation (Lugnot et al., 2013). The valuation work conducted by ecological economists is not easily understood by the general public and may be difficult to communicate and incorporate into policy (Karrasch et al., 2014).

Although there is scientific understanding of the role of natural infrastructure in mitigating coastal hazards risk and the amplification of hazards as a result of deteriorated natural systems, public understanding of the same is poor (Tunstall, 2000). The lack of public support for the utilization of natural infrastructure for hazard mitigation might be due to a lack of public understanding of the functions of ecosystems. Karrasch et al. (2014) found less than a third of the sector-specific stakeholders they interviewed had an awareness of the mitigation functions of natural infrastructure and most stakeholder sectors (except the nature conservation interests) favored engineered infrastructure. Stakeholder dialogue changed when the researchers explained the functions of the coastal ecosystems in reducing coastal hazards, indicating a change in awareness of the advantages to incorporating natural infrastructure. It has been found that through on-the-ground work with local communities, such as sharing information on vulnerability (sea level rise, land use and shoreline changes), the public's understanding of the role of vegetation (a form of natural infrastructure) in protecting against coastal erosion is enhanced (Mustelin et al., 2010). Greater awareness of the functions of natural infrastructure can influence perceptions and preferences for its use in integrated or comprehensive mitigation strategies. Since members of the public in coastal communities are so important to the governance process, understanding their current awareness of natural infrastructure will aid in the governance process and indicate what communication and information might need to be shared to improve discussions around comprehensive policies that incorporate natural infrastructure.

Media news following Superstorm Sandy documented that the general public does have an awareness of the role of natural infrastructure in mitigating risk and the belief that there has not been enough investment in natural infrastructure as part of mitigation solutions (Florescu, 2013; Fountain, 2013). A poll conducted by the Monmouth University Polling Institute and the *Asbury Park Press* a month after the storm found that more than two-thirds of New Jersey residents support expenditures to restore existing wetlands and bays to serve as natural "storm buffers" (Murray, 2012). This public perceptions of natural infrastructure providing coastal hazard mitigation is promising and suggests that empirical research into public perceptions of mitigation strategies that includes perception of the function of natural infrastructure may uncover why certain strategies are preferred. Research conducted by the New Jersey Climate Adaptation Alliance (NJCAA, 2013a; NJCAA, 2013b) (also after Superstorm Sandy) found that stakeholders from sectors such as local government, agriculture, emergency management, planning, social services, land conservation, and water resources strongly support restoration of coastal wetlands for purposes of their provision of habitat and water quality improvement rather than hazard mitigation. Similarly, researchers at Middlesex University in the United Kingdom (UK) found that the concern of stakeholders and decision-makers regarding the loss of natural infrastructure, such as coastal wetlands, is related to ecological value and environmental protection not risk mitigation per se (Tunstall, 2000). Direct investigation of local public perceptions of natural infrastructure will complement findings from previous research with stakeholder groups.

In surveying Louisiana residents' perception of wetlands restoration benefits, Kim and Petrolia (2013) found that the majority of the respondents were aware of wetland loss as a problem and the role of coastal wetlands in mitigating the impacts from storms. Reduction in hurricane protection was the leading consequence of wetland loss identified by respondents, and more than half believed wetland restoration would reduce storm impacts. Those perceived hazard mitigation benefits provided by wetlands were conditioned on the perceived frequency and intensity of storms: those respondents that anticipated a high frequency of Category 3 or stronger storms were less likely to believe there would be storm reduction benefits from wetland restoration. This is consistent with scientific evidence: natural infrastructure, such as wetlands, reduce impact from high frequency, low intensity storm events (Arkema et al., 2013; Shepard et al., 2011; Spalding, McIvor, et al., 2014). In studying public perceptions of wetland restoration with a questionnaire survey of Spanish residents, Curado et al. (2014) also found that some residents recognized the function of wetlands in providing flood control, albeit less than the perceived benefits of habitat provision and aesthetics. Although neither study investigated the public perceptions of engineered infrastructure or the relationship between wetland function and that of engineered infrastructure, existing research suggests that, upon direct inquiry, local residents' awareness and perception of natural infrastructure can be uncovered. Members of the public may be able to express their understanding of the functions of natural infrastructure if asked directed about specific natural features such as coastal wetlands or dune systems.

Some researchers have investigated stakeholder perceptions of coastal hazard mitigation infrastructure, yet limited their investigations involving residents and, despite polls, the research presenting the public perceptions of natural infrastructure in providing hazard mitigation in coastal regions is very limited. There is not much empirical evidence of public perception of or preferences for natural infrastructure in coastal regions pertaining to coastal hazard mitigation. Therefore, it is not clear what costs or trade-offs the public is willing to accept since there is limited assessment of public knowledge of natural infrastructure in hazard mitigation (Loomis et al., 2014).

Experience with and awareness of coastal ecosystems or natural infrastructure projects can enhance perception of the benefits natural infrastructure can provide in reducing coastal hazards and the impacts from them. Experience or familiarity with mitigation strategies that incorporate natural infrastructure is a strong factor in perception of effectiveness (Roca et al., 2012). Myatt et al. (2003) found that only those residents who were aware of a managed realignment scheme offered opinions on the use of natural infrastructure and those opinions were favorable: they perceived the scheme as providing risk mitigation through reduction of wave energy and flooding and providing more protection than engineered structures alone. It is important to study residents' perception of natural and engineered infrastructure in coastal locations that have both types of infrastructures.

Prioritizing ecosystems for conservation or restoration to provide coastal mitigation not only requires an appreciation of their functions, but also knowledge of where they are most likely to reduce coastal hazards. Although scientists have studied how ecosystems' function to provide hazard mitigation, there is limited research that shows if local knowledge has been used to locate or identify existing natural infrastructure that has served to mitigate hazards. Gedan et al. (2011) cited anecdotal evidence of the cultural behavior of planting mangroves as shelter to protect coastal properties in the Philippines as indicative of a local understanding of the role of coastal vegetation in providing protection against coastal hazards. Another reason to investigate public perceptions of mitigation infrastructure in the communities at risk and with existing natural features and engineered structures is the possibility of uncovering perception informed by experience with those mitigation infrastructures.

We do not understand the public's preferences for or how the public perceives the role of natural infrastructure in coastal areas (Loomis et al., 2014). This lack of understanding limits how to best ensure natural infrastructure will be integrated into coastal hazard mitigation strategies. This research expands on and addresses the limitations of previous work by investigating the perception of residents in at-risk coastal communities towards both the functions of and relationships between natural and engineered mitigation infrastructure. Only once there is an understanding of how people think about these infrastructures can governance produce comprehensive mitigation strategies by addressing the public's concerns and preferences.

CHAPTER 3

STUDY AREAS

New Jersey, a coastal state of the United States, has many communities exposed to coastal hazards and most have engineered infrastructure and some also have natural infrastructure that serves to mitigate coastal hazards. Two of these communities in the Raritan Bayshore region of New Jersey were selected for this research, (1) Laurence Harbor, Old Bridge Township and (2) the Borough of Union Beach. The coastal areas of the Raritan Bayshore experience similar hydrometerological conditions, but the two locations have differing topographies and geomorphologies and therefore are affected differently by coastal hazards differently. Both communities have similar engineered structures that were designed for coastal hazard mitigation and have natural features that may serve to mitigate coastal risk. Both communities experienced damages from Superstorm Sandy (October 2012). They are also the focus of federal, state and local interest in engineered infrastructure and restoration of natural infrastructure. This research was timely as these communities were still recovering from Superstorm Sandy and have mitigation projects and plans under development that will rely on public acceptance.

3.1 Raritan Bayshore, New Jersey

New Jersey is the most densely populated state in the United States, and its development has extended to almost every reach of its 210 miles of (ocean and bay) coastline. Over 75% of the land area of the state is defined as coastal and contains 60% of the population (NOAA, 2014). New Jersey's waterfronts serve as economic engines for its ports, fishing, tourism, and recreation. The drivers of urbanization in New Jersey are numerous: the greatest is the State's proximity to New York City and Philadelphia, making it a corridor for transport of people and products, industrial growth, and residential development (Stansfield, 2004). Together these drivers have spread New Jersey's urbanization to the coast as evidenced by explosive population growth and extensive landscape modifications (Mitchell, 1976).

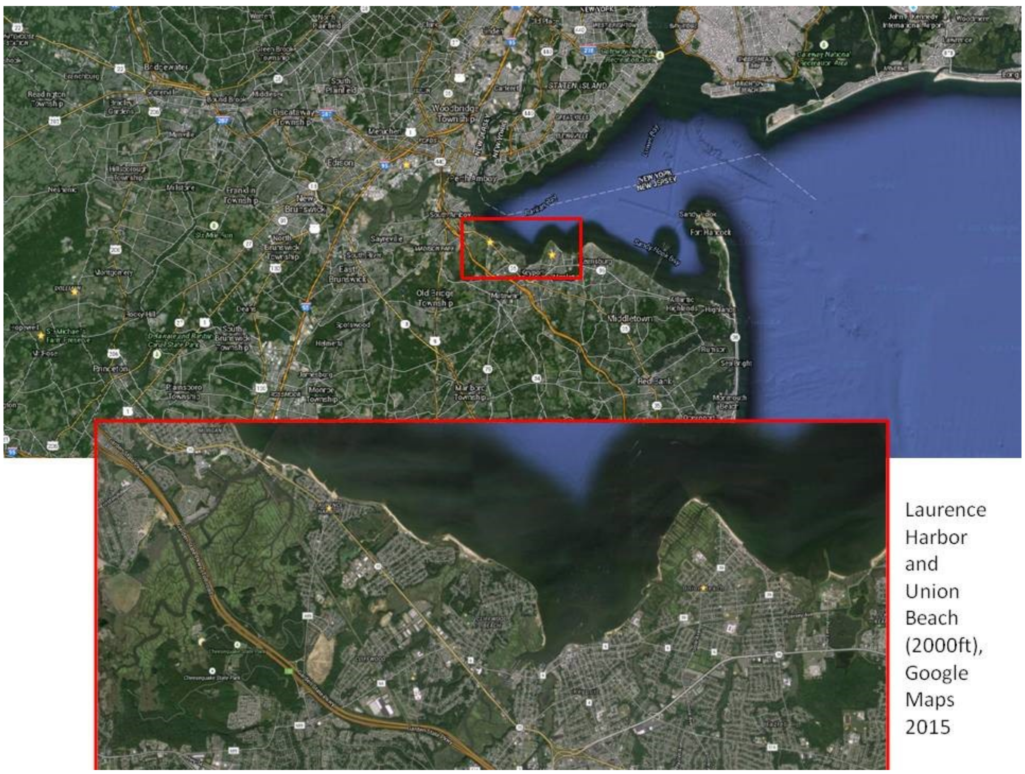

Figure 3.1 Aerial map of study areas in the Raritan Bayshore.
Source: Google Maps (2015)

The Raritan Bayshore (Bayshore) region of New Jersey is a unique, little explored case of New Jersey's development of the coast: The Bayshore's history predates the explosion of development along the Atlantic coast of New Jersey, the area most thought of when one hears of the "Jersey Shore". The Bayshore extends approximately twelve (12) miles east from South Amboy to Port Monmouth, just west of Sandy Hook Bay, and includes part of Middlesex and Monmouth counties. The drivers of the Bayshore's urbanization are its proximity to New York City and the northern New Jersey metropolitan areas as well as its coastal and waterfront amenities and associated economic opportunities. However, this region has shown an economic decline over the last few decades. The Bayshore featured early, pre-20th century, uses of the waterfront for fishing and maritime industries, agricultural shipping as well as the pottery industry and then became a summertime shore destination for travelers from New York City. The Bayshore was popular as a summertime resort during the 1920s through the 1940s. Local tourist attractions such as hotels, boarding houses, camp resorts all accessible from New York City (The Monmouth Musuem, 1990). The summer homes that came with 1920s development laid the foundation for the now year-round communities of the Bayshore. There was a stable population in the region during the 1930s and 1940s and a rapid in-migration in the 1950s (Monmouth County Planning Board, 1959). During the 1940s and the post-war period there was a 41% population increase in the region. In the late 1950s, the construction of the Garden State Parkway (GSP) made the area commutable to live and get to work, adding to the explosive population growth. By the mid-20th century, most of the summer cottages had already been converted to year-round homes and the area was mostly full-time residential with a concurrent decline of the area as a tourist destination. The population growth trends in late 20th century were less than the rest of the county and the median income and house price was lower than that of both the county and the State as a whole (Post et al., 1985). Many of the patterns created with the 1920s development are etched in contemporary layout and land use, minus the waterfront amenities which were destroyed in the 1950s and 1960s by hurricanes, and consequently never rebuilt.

The socio-economic demographics of the two study areas are similar. The median household incomes for the two study areas are higher than for the State as a whole, but lower than similar coastal towns along the Atlantic coast of New Jersey, such as Oceanport where the median age is also higher (45 years versus 39 years in both Union Beach and Laurence Harbor) (City-Data.com, 2016a). In 2013, the estimated median household incomes of Laurence Harbor (LH) and Union Beach (UB) were $72,334 and $75,683, respectively, where in Oceanport they were $92,957. Similarly, the estimated median home value in the two study areas ($245,674 (LH) and $253,115 (UB)) were much lower than Oceanport ($458,399) and slightly lower the state as a whole ($307,700).

3.1.1 Geography and Physical Processes

The two study areas are part of the Raritan Bayshore which is a subaerial portion of the New Jersey Coastal Plain with marshes that border streams and submerged valleys (USACE, 1960). Ocean waves entering the bay are modified from the effects of refraction and shoaling changing wave height and direction. Computations in the middle of last century indicate waves as high as 14ft (swells of 15ft) are possible off Point Comfort, Keansburg. Waves are also generated from local east and east-northeast winds across the open bay (Coastal Planning & Engineering et al., 1993). Maximum wave height in 1993 at Cheesequake Creek, which abuts Laurence Harbor, was estimated at 7ft at a period of 6.5 seconds. The breaking wave height governs nearshore processes. The 100-yr return interval breaking wave depth under a storm tide level of 11.3ft MSL is 8.8ft.

Tidal currents in the lower Raritan Bay are generally weak except at entrances to the Raritan and Shrewsbury Rivers; circulation occurs in relatively deep water (2 miles off shore). Tides are semi-diurnal with mean range 5ft (South Amboy) to 4.7ft (Atlantic

Highlands), with spring tides 6-5.7ft, respectively (Coastal Planning & Engineering et al., 1993). As of 1993, the maximum stormwater elevation in the Raritan Bay was during Hurricane Donna (1960) at 10.3ft above mean sea level (MSL). During Superstorm Sandy, the tide elevation in the region was over 8ft MHHW. Projections for SLR in 1993 were a total of 0.7ft over the 50-year life of coastal engineered projects. The current MSL trend for Sandy Hook is 4.8mm/ year (NOAA, 2013). Current projections of local SRL range from 0.6-1.8ft by 2050 (Strauss et al., 2014).

Tidal creeks and flats, associated coastal marshes, and freshwater wetlands characterize the Raritan Bayshore. Over the years, many of the previous marshes and wetlands have been drained, altered, or replaced by development (Coastal Planning & Engineering et al., 1993). A number of engineered structures have further enhanced the degradation of the ecosystem in the Bayshore (HEP, 2012; USACE, 2014a). The topography of Union Beach is low, flat terrain, traversed by several creeks and wide stretches of swampy marshland located along creeks and a portion of the shoreline. The western part of Union Beach, also known as Conaskonk Point, is characterized as unprotected marsh. There is no indication of net littoral drift in that direction of Union Beach. Laurence Harbor is surrounded by diverse wetlands and bay front with areas of waterfront cliffs.

3.1.2 Coastal Hazards

The Raritan Bayshore is subject to damage from hurricanes (August-October) and extratropical cyclones (northeasters) (USACE, 1960). The wind field of northeasters is less symmetrical than hurricanes and covers a greater area producing prolonged periods of onshore flooding. Flood damage by northeasters is a function of duration rather than intensity (Coastal Planning & Engineering et al., 1993). Hurricanes, due to intensity, cause high wind speed and high surge. In the middle of last century, the frequency of unusually severe storm occurrences per 100 years was 3.6 and severe storms at a frequency of 14 times per 100 years. There were six (6) unusually severe (Category A) and sixteen (16) severe (Cat. B) storms from over a three-century period of 1635-1950 with twelve (12) of the sixteen (16) occurring during the last sixty years of the period. Tidal flooding created by high winds, low pressure and accompanying wave action result from these storm events. Bay surge and associated flooding is caused by a combination of storm induced water levels and astronomical tide (Coastal Planning & Engineering et al., 1993). Tidal flooding is expected to increase in severity in relation to SRL. Bulkheads and beach fill offers limited protection against tidal flooding.

Shore erosion in the region has resulted in reduction of beach width exposing development to wave attack as well as loss of recreational use (USACE, 1960). Shoreline erosion has eliminated most of the beachfront and resulted in deterioration of existing coastal protection and drainage structures. In many areas, blockage of the existing storm drainage system compounds the extent and duration of flooding (Coastal Planning & Engineering et al., 1993). Although bulkheads and seawalls have been useful at holding the shoreline, seaward beaches have been lost to erosion. Littoral forces cannot be depended upon since drift is very small and varies, thus the relatively little accumulation of material at existing groins and jetties. Erosion of shorelines between 1836-1957 was 55ft for Cheesequake to Matawan Creeks (includes Laurence Harbor) and 154ft for the reach between Matawan and Compton Creeks (includes Union Beach and Keansburg), with the greatest erosion during the earliest period of record (1837-1856). Although extensive bulkhead construction is cited as a main reason for the less dramatic erosion, 4ft of erosion occurred between 1932-1957 in the region that includes Union Beach even with existing bulkheads and the 318,000 cubic yards (CY) of fill emplaced during that period.

The flat gradient and low relief of surrounding terrain in Union Beach and surrounding areas makes them extremely vulnerable to flooding during heavy rainfall, whencreeks overtop and spread flood waters over a broad flood plain, eliminating drainage of interior areas (Coastal Planning & Engineering et al., 1993). Extensive development has occurred up to the very edge of surrounding wetlands. The highly developed nature of the Bayshore area has adversely affected the function of previously productive and protective wetlands. Historically, severe tidal inundation occurs as water floods the remaining low-lying wetlands surrounding the borough. Tidal flooding comes from Chingarora, Flat and East Creeks in Union Beach (USACE, 2003). Along low-lying areas and due to the numerous creeks and waterways that intersect the shoreline, normal high tides frequently flood the area as a result of interior peak flows coinciding with high tides and/ or storm surge.

Extensive flooding of these highly developed communities results from storm driven tides and waves (Coastal Planning & Engineering et al., 1993). USACE reports have identified the need for better stormwater controls from surface runoff (Coastal Planning & Engineering et al., 1993; USACE, 1960). Flooding has resulted in extensive damage to property, loss of life, evacuations, and significant constraints on regional economic development.

3.1.3 Mitigation Infrastructure

The two study areas are subject to similar physical coastal processes although variations exist in the specific nature of the impacts of coastal hazards based on the differences in the topography of the areas. The two areas have similar mitigation infrastructure. The Union Beach shoreline includes engineered structures (groin, bulkhead and stone revetment), low natural dunes or beaches, and shoreline marshes (Coastal Planning & Engineering et al., 1993). Most of Laurence Harbor sits on top a bluff and the area is flanked by coastal wetlands. There are areas of high natural or constructed dunes. There are three groins and a stone revetment along the beach and a rock armoring at the base of the bluff.

Federal investment

The USACE explores coastal hazard mitigation projects through feasibility and reconnaissance studies which includes documenting the benefits and costs associated with installing engineered structures (USACE, 2004). The USACE pursues coastal hazard mitigation projects to control erosion and to reduce impacts from storms when there is an identified need that is beyond local government's capacity to address. Federal investment is justified when the benefits from potential reductions in hazards exceed the costs. The USACE pursues projects in coastal areas where there are a number of assets and people to protect, which is the case in the majority of the New Jersey Raritan Bay and Atlantic coast.

The USACE has a number of hurricane and storm damage reduction projects in different stages for the Raritan Bayshore (USACE, 2015a; USACE, 2015b; USACE, 2015c). According to a USACE report (1993), the greatest need for the Bayshore region is protection from flooding and restoration and stabilization of the shorelines. According to Jenifer Thalhauser, USACE NY District and project manager for the Raritan Bay region:

"Coastal flood risk management projects are formulated to address storm impacts caused by three independent damage mechanisms: erosion, wave attack, and inundation. During the formulation process different alternatives are considered (e.g., beach berm, sea walls, nonstructural measures, etc.) to address these impacts" (Asbury Park Press, 2013).

Engineered measures installed prior to 1960 include several bulkheads and groins, a few sea walls and some artificial beaches (USACE, 1960). Levee improvements were determined to be necessary along the flanks of protected areas. Federal projects have included two (west-east) stone jetties at Cheesequake Creek (1883). Over time, due to storm damage, the two Cheesequake jetties have been reduced in size. In 1935, 25 groins and about 2,500 feet of bulkhead were constructed in Laurence Harbor, Old Bridge (formally Madison Township). The groins have generally not been successful in trapping material resulting in narrow beaches, and the bulkheads have been ineffective at holding the shore. In 1953, the State and township constructed a 1,263ft bulkhead along Morgan Beach and Laurence Harbor. State projects have included a timber bulkhead in Union Beach (1954). Another bulkhead was constructed privately before 1930.

In its 1960 study, the USACE concluded that multiple-purpose shore and hurricane protection (beach fill, groins, levees and interior drainage facilities) was determined to be feasible for Old Bridge and single-purpose shore protection (beach fill) for Union Beach. Groins would hold the beach fill and levees would prevent bay waters from flanking improved beaches. Beach fill would help to dissipate wave energy and prevent tidal inundation. These projects were authorized in 1962. The incorporation of hurricane protection for Union Beach was not economically justified in the study as it was stated it would greatly interfere with economic development (USACE, 1960, 2003).

The USACE conducted a three-year comprehensive study to evaluate the effects of Superstorm Sandy and to provide a risk management framework for the North Atlantic Coast which included evaluating the use of both engineered and natural infrastructure (USACE, 2015). Study areas included the Lower Raritan Bay with Union Beach and Laurence Harbor. Their analysis suggested that features within this reach that could mitigate risk included beaches, sheltered manmade (engineered) structures, scarps, and sheltered wetlands. The risk reduction potential is high (1% chance flood plus 3ft) from beaches (highest for restoration with breakwaters) and sheltered manmade structures (highest for deployable flood walls), and low (10% chance flood) for scarps (highest for reefs) or sheltered wetlands.

In addition, the Hudson-Raritan Estuary Comprehensive Restoration Plan (CRP), also under the jurisdiction of the USACE and informed by USEPA's NY-NJ Harbor Estuary Program (HEP) and regional stakeholders, has the purpose to restore the estuary ecosystem recognized for its ecosystem services (USACE, February 2015; USACE, March 2009; USACE, September 2014). The CRP proposes restoration of 200 acres of wetlands most which have been degraded or destroyed by human activities (USACE, March 2009). Since Sandy, there is an emerging interest among the stakeholders of the CRP in the role of the harbor ecosystem in regional resilience recognizing the efficacy of "nature-based" resiliency features being critical to achieving their restoration goals (HEP, 2014; USACE, September 2014). A number of natural infrastructure restoration projects in the study areas are identified in the CRP (2014a).

3.2 Laurence Harbor, Old Bridge, Middlesex County

Laurence Harbor is 2.95 square miles located in the Township of Old Bridge, Middlesex County, NJ next to Cheesequake State Park. In 2013, the population of Laurence Harbor was 6,496, a 5% increase from 2000 (City-Data.com, 2016a). The median age of residents in 2010 was 39.7 years.

Characteristic of the Raritan Bayshore as a whole, from the 1920s through the 1940s, Laurence Harbor consisted of small bungalows used as summer homes. Before the construction of the GSP, it was a destination shore area (McCay et al., 2005). During the 1950s many of these summer cottages were converted into year-round residences and some larger homes were constructed, especially on the bluff. The majority of the waterfront is publicly accessible and the coast is used for passive and active recreation. In 2002, a county park was developed, a two-mile-long tidal basin known as Old Bridge Waterfront Park that consisted of a new boardwalk (the old boardwalk was destroyed in the 1940-1950s). (The boardwalk has since been reconstructed again after Sandy.) The park's boardwalk is popular for jogging and dog walking. The area is also popular for fishing commonly from the groins that extend into the Raritan Bay. At the northern parking lot of the park, there is bay beach swimming access along with a bathroom and showers. Because of the tidal action and shallow water levels, there are not many commercial waterfront uses (McCay et al., 2005). There are a couple of marinas along the Cheesequake inlet.

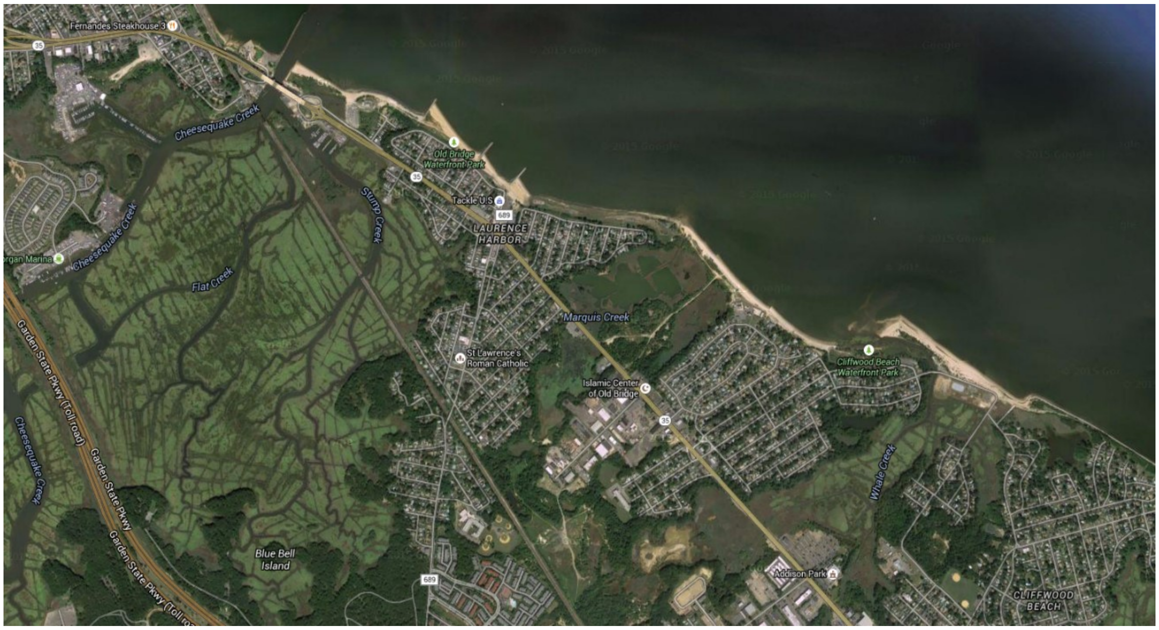

Figure 3.2 Aerial map of Laurence Harbor, Old Bridge (1000ft).
Source: Google Maps, 2015

Mitigation Infrastructure

The USACE flood risk management project authorized in 1962 was constructed in 1966 in Laurence Harbor and was part of the regional project that extended to Keansburg and East Keansburg. The project included protective beaches and dunes for 1.7 miles at 5.5ft (beach), 10ft (bluff) and 15ft (hurricane protection) above mean sea level, 0.4 miles of levees at elevation of 15ft above sea level and interior drainage facilities (Coastal Planning & Engineering et al., 1993). The historic project provided 789,000 CY of fill at berm elevations of 5.5 and 15ft MSL. Since the original design, the area has experienced 0.5ft of sea level rise (SLR) and 2009 Flood Insurance Rate Maps (FIRMs) considered the project to not provide effective protection for a 100-year storm event, despite being designed for a 200-year storm in 1962 (USACE, 2013b).

A 1993 flood mitigation reconnaissance study of the region reported that Laurence Harbor's engineered structures have been ineffective in shoreline protection except for the eastern portion with evidence of lack of dry sand beach seaward of the structures when comparing aerial changes over time (Coastal Planning & Engineering et al., 1993). Although the jetty at Cheesequake Creek does trap sand and stabilizes the updrift shoreline, severe shoaling occurs in the Cheesequake channel. The groins cause downward negative impacts evidenced by shoreline offset at each groin. No littoral drift occurs west of Laurence Harbor.

Figure 3.3 Laurence Harbor aerial (500ft), showing location of groins, seawall revetment, beach, maritime forest and wetlands.
Source: Google maps, 2015

A complicated situation over the engineered infrastructure at Laurence Harbor exists: it makes up part of a designated Superfund Site with the presence of metal slag in the seawall/ revetment and groins in the area (USEPA, 2009). Known as the Raritan Bay Slag Site, it spans approximately 1.3 miles in length and consists of the waterfront area between Margaret's Creek and the area just beyond the western jetty at the Cheesequake Creek Inlet. The portion of the site that is situated in Laurence Harbor is part of Old Bridge Waterfront Park. The contamination was discovered when the New Jersey Department of

Environmental Protection (NJDEP) Green Acres Program was pursuing purchase of the Margaret's (Marquis) Creek portion of Laurence Harbor from Old Bridge Township in 2006 and historic aerial photos revealed that approximately 20 acres of the site was filled prior to 1974 with shredded automotive battery casings and refractory brick and slag. Similar material was found as part of the seawall/ revetment and groins in Laurence Harbor. Soil samples showed associated elevated levels of lead along with arsenic and antimony. Approximately 2,500 feet of the revetment was contaminated. Since 2009, access to certain areas has been restricted, and USEPA entered into agreement with the USACE to conduct a Remedial Investigation/Feasibility Study. In 2013, a Record of Decision for the site was signed and includes excavation/dredging and off-site disposal (USEPA, 2013). Slag, battery casings and contaminated sediment are to be excavated.

In 1996, federal authorization was given for a 50-year re-nourishment of the 1962 beach erosion control and hurricane protection project (Elias, 2013). A re-evaluation study for the nourishment began in 1999 and was released for public review in 2007. Pre-solicitations for the work went out in March 2013. Two contracts were awarded in the summer of 2013 for the repair of levees and beach restoration of the 1962 project. Work began in 2014.

In a post-Sandy Performance Evaluation Study, the USACE reported that the engineered infrastructure (beach berm and levees) constructed in 1966 in Laurence Harbor performed better than expected despite the extreme storm tides (+9ft MHHW (mean higher high water: the average height of the higher high waters over a 19-year period)) and waves (>30ft offshore wave heights) exceeding design conditions (USACE, 2013b). The pre-storm condition of the infrastructure was considered "fair". Sandy's storm tide overtopped the berm 8ft in some areas and resulting erosion caused the berm to be narrowed and lowered by 5ft in some areas. Beach erosion was 0.3 million cubic yards (MCY).

The Hudson-Raritan Estuary Comprehensive Restoration Plan (CRP) (2014a) includes a few restoration priorities in the waterfront sections of Old Bridge (Laurence Harbor):

- Marquis Creek (aka. Margaret's Creek) lies between Laurence Harbor and Cliffwood Beach in Old Bridge Township. The Marquis Creek site is comprised of areas of salt marsh degraded by dumping and filling as well as a narrow tidal creek, beach, and upland areas. The wetlands of Margaret's Creek are a mixture of unconsolidated shore with organic soil and emergent wetlands that are vegetated and partially flooded. It is also part of the Raritan Bay Slag Superfund Site. Plans include permanent protection and wetland/ upland restoration.

- Laurence Harbor shoreline, also part of the Slag Superfund site, includes the Old Bridge Waterfront Park and the seawall and jetties constructed partially from the metal slag. Plans include wetland restoration couple with the capping activities, re-grading and replanting wetland vegetation as well as restoration of forested upland and dune vegetation.

Superstorm Sandy's Impacts to Laurence Harbor

Superstorm Sandy's storm surge, estimated to be in excess of 15–20 feet above sea level along the Raritan Bay, destroyed portions of the Old Bridge Waterfront Park in Laurence Harbor: the entire boardwalk was washed out, including one of the new jetties (USACE, 2013b). The houses along the waterfront boardwalk had no flood damage, some had minor wind damage. A small section of the town below the shore ledge did have flood damage. Existing erosion of the cliff in Laurence Harbor was made worse from Superstorm Sandy. Following the storm, massive improvements to the boardwalk jetty and parks were performed. There is now a new park, boardwalk, railings on the groins, and boulder rocks along the cliff to protect against further erosion.

Laurence Harbor did not have as extensive flooding or wind damage from Superstorm Sandy as did Union Beach. There were reports of a tidal wave overtopping of a stone seawall near Bayshore Avenue causing damage to homes in the vicinity. According to early FEMA assessment reports, 8 structures in Laurence Harbor had minor damage, 5 structures had major damage and only 2 were destroyed (Sagara, 2012) (descriptions of these assessment categories are given in the legend of Figure 3.5.). Figure 3.4 shows the areas inundated from Superstorm Sandy storm surge and Figure 3.5 shows the approximate location of affected structures based on FEMA assessments and flood depth.

Of note, on December 8, 2015, the New Jersey Department of Environmental Protection announced its first Blue Acres buyout on Clifford Way in Lawrence Harbor (NJDEP, 2015). Blue Acres is a New Jersey program in which the State pays fair market value to acquire flood-prone properties. Clifford Way and Bayshore Avenue is the area of Laurence Harbor shown in Figure 3.5 by high concentration of orange markers.

Figure 3.4 Extent of storm surge from Superstorm Sandy in Laurence Harbor, New Jersey.
Source: Rutgers Floodmapper (2016) accessed June 25, 2016: http://slrviewer.rutgers.edu/

Figure 3.5 Damage assessment of Laurence Harbor from Superstorm Sandy at the building level: color-coding represents damage classes derived from a combination of imagery-based assessments and flood depth: Tan ("affected"): Generally superficial damage to solid structures, light structures damaged or displaced, observed flood depth: >0 to 2ft; Yellow ("minor"): Solid structures sustained exterior damage, light structures destroyed, many damaged or displaced, observed flood depth 2 to 5ft; Orange ("Major"): Some solid structures are destroyed; most exterior and interior damage, light structures destroyed, extensive structural damage and/or partial collapse due to surge impacts, observed flood depth > 5ft. Red ("Destroyed"): Most solid and all light structures destroyed or washed away by surge.
Source (accessed November 17, 2016):
http://services.femadata.com/arcgis/rest/services/2012_Sandy/Imagery_Based_PDA/MapServer/layers

3.3 Union Beach, Monmouth County

Union Beach is about 1.83 square miles with approximately 3.8 miles of coastline in northeastern Monmouth County, New Jersey. It is bordered to the east by Keansburg Borough and the Thomas Creek, to the south by Hazlet Township, to the west by Keyport Borough and the Chingarora Creek, and to the north by Raritan Bay. An aerial map of Union Beach is shown in Figure 3.6. The Borough also has two creeks that run north to south through the Borough, the Flat Creek and the East Creek (T&M Associates, 2014). In 2014, Union Beach had a population of 5,700 a 14% decrease from 2000 (City-Data.com, 2016b). The median age of residents in 2010 was 39.8 years, similar to Laurence Harbor. The estimated median household income was $75,683, slightly higher than Laurence Harbor, and home values were estimated at $253,115.

Union Beach was developed as a commercial/ industrial area as well as a beach resort (McCay et al., 2005). In the 1880s, fishing and marine farming provided a livelihood for residents. In the late 1880s, brick manufacturing was active in the Natco section of Union Beach. In the 1920s, a summer campground was established. An amusement park was destroyed during a hurricane in the 1950s. There are no marinas on the Bay. A chemical manufacturing company used to occupy waterfront land in the eastern section of Union Beach. Until late 2000s, the northeastern and western portions of the waterfront were zoned "heavy industrial." Although much of the industrially-zoned areas have been replaced with parks or wetlands, some industrial areas still exist in environmentally sensitive areas and along the waterfront (Coastal Planning & Engineering et al., 1993). The Borough has used State Green Acres funds to purchase waterfront open space for public use. According to the Borough's 2005 Land Use Plan Element, Union Beach is primarily characterized by residential uses (comprising 36.3% of the Borough's entire land area) and vacant land (comprising 26.1%) (T&M Associates, 2014). Other land uses in the Borough include rights-of-way/riparian lands (13.3%), industrial (11.4%), public environmentally constrained open space (11.3%), active recreation (3.5%), public/quasi-public (2.8%), and commercial (1.6%).

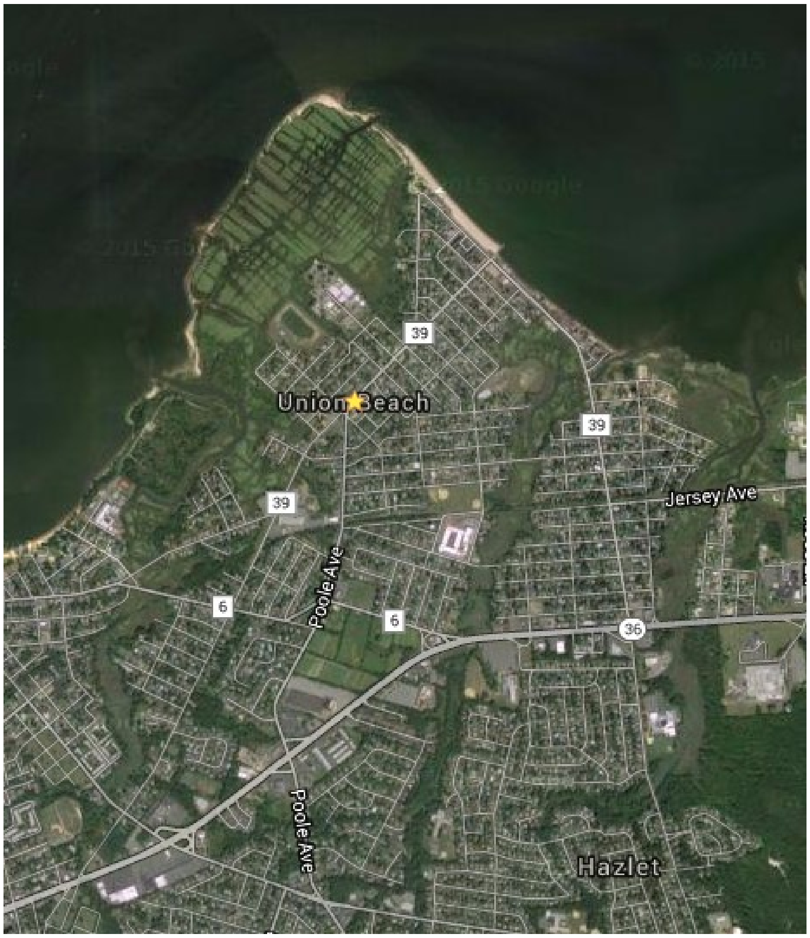

Figure 3.6 Aerial map of Union Beach (1000ft).
Source: Google maps, 2015

Most of the town's development is between the boundary of the western marshland and East Creek. All development between Flat and Chingarora Creeks was 16ft below sea level in 1993, thus a majority of buildings are in the 100-yr flood plain (Coastal Planning & Engineering et al., 1993). There is slight elevation (20ft+ MSL) between East and Thorn's Creeks providing some flood protection. Roughly 90% of Union Beach's land is located in a flood hazard area, and this includes a majority of the Borough's buildings and key community facilities (T&M Associates, 2014). The 1962 Master Plan for Union Beach identified the major creeks in the area, Flat, East and Chingarora, as potential recreational opportunities if only "proper flood control measures" were taken. The plan also recognized that an engineered flood protection project would enable the Borough to improve a number of 'bad' drainage conditions and expand on beach front facilities (Herbert H. Smith Associates, 1962).

The 2003 Floodplain Management Plan recommends a complete flood protection system to include a combination of structural measures, home acquisition, elevation and setbacks, residential flood proofing, infrastructure improvement, warning systems and erosion and sediment control. Union Beach has been participating in FEMA's Community Rating System (CRS) since 2003 which gives discounts on flood insurance premiums as a result of activities such as elevations, education, open space preservation, stormwater management and a floodplain mitigation plan.

Mitigation Infrastructure

The existing engineered and natural infrastructure in Union Beach is shown in Figure 3.7. The western portion of Union Beach is characterized by unprotected low-lying marsh and some beach with the eastern shoreline just unprotected marsh (USACE, 2003). The 1962 authorized Union Beach Project provided fill for 0.6 miles at 5.5ft above sea level. The developed section of the Borough is protected with an assortment of privately constructed bulkheads and seawalls. The developed coastline along the Bay is protected by a locally constructed 1,850-foot wooden bulkhead paralleling Front Street and ending at Union Avenue with no dry beach seaward. Higher bluffs at East Creek are tied to the levee closure system for Keansburg. The interior drainage system contains 38 outfalls.

Figure 3.7 Aerial map of Union Beach (500ft) showing location of groin, bulkhead/ stone revetment, beach, dunes, maritime forest and wetlands.
Source of aerial: Google Maps, 2015

In Union Beach, an engineered infrastructure project that includes a combination of levees and floodwalls, tide gates, pump stations, and beach and dune berms (USACE, 2015b) was finally announced in April 2015 (the schematic of the design is shown in Figure 3.8). The project requires, as per the ecosystem restoration requirement of the USACE mission, twenty-five acres of wetland mitigation. This project was in the Preconstruction, Engineering and Design (PED) phase when Superstorm Sandy stuck in late 2012; it had to go through a limited re-evaluation. The Feasibility Report and Environmental Impact Statement (EIS) had already been released to the public in 2004 and approved by USACE Headquarters in 2006, and the Value Engineering Report presented to the State and the Borough of Union Beach in 2011.

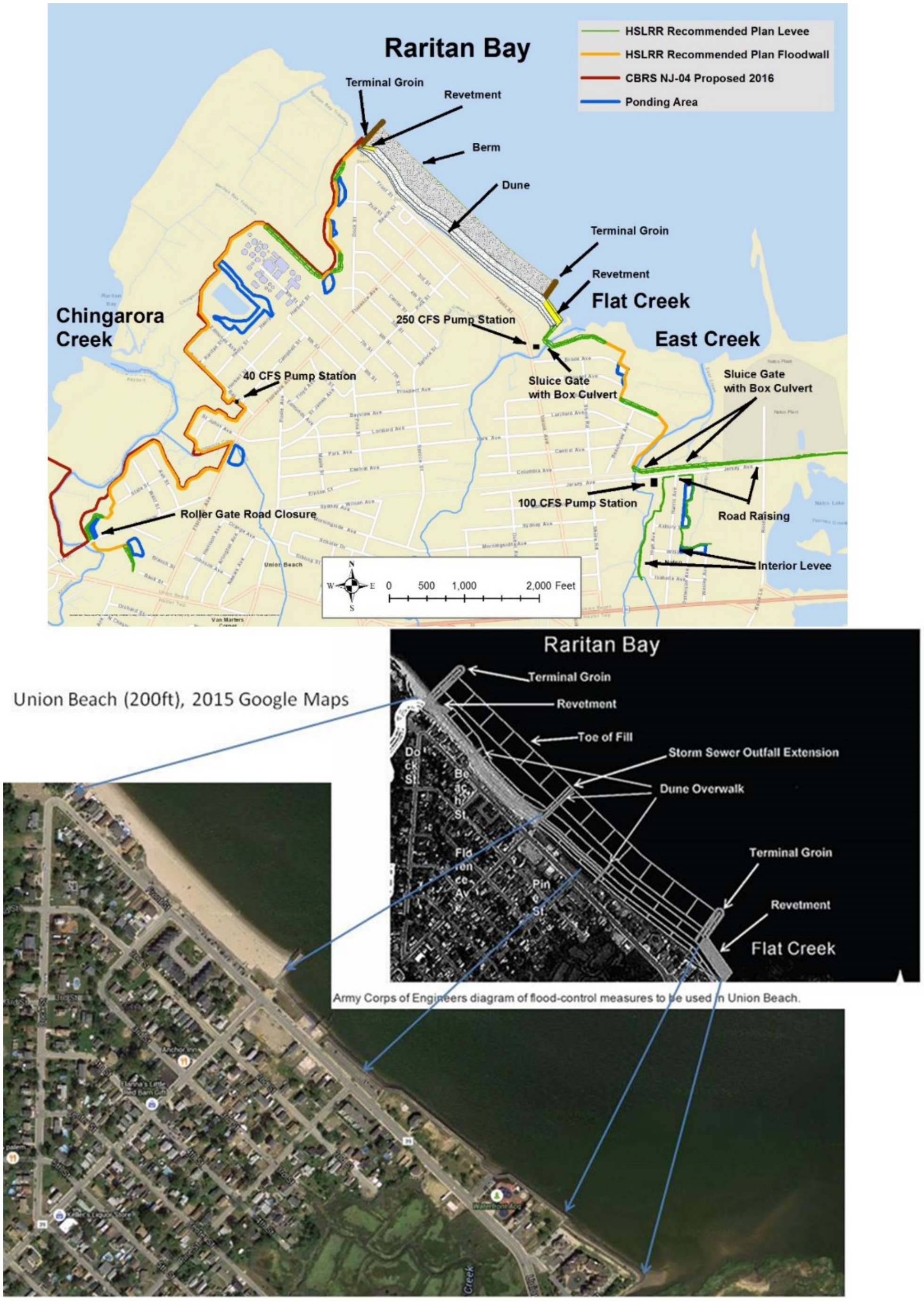

Figure 3.8 USACE flood protection project for Union Beach, authorized Spring 2015. The shorefront details are highlighted on the aerial map of Union Beach (200ft).
Source of aerial: Google Maps (2015) and schematic of engineered works: (USACE, 2016)

The Hudson-Raritan Estuary CRP (2014a) includes a few restoration priorities for Union Beach to include:

- Natco Lake/ Thorns Creek, located on the border of Hazlet and Union Beach, is identified for restoration and regrading of the 260 acres' intertidal marsh and tide channel to improve hydrology as well as restoration of the upland wooden buffer (maritime forest).

- East Creek located in same area is recommended for permanent protection and restoration of the tidal marsh, potential stream enhancement, and restoration of the upland wooden buffer. Plans would be consistent with the USACE Storm Management and Ecosystem Restoration studies and the Union Beach Stormwater Management Plan.

- Flat Creek in Union Beach has large tracks of wetlands. Due to erosion and sedimentation the Creek is unable to handle high volumes of stormwater. The CRP project is for permanent protection and restoration of the tidal marsh, stream enhancement, and restoration of the upland wooden buffer. This would also be consistent with the USACE Storm Management and Ecosystem Restoration studies and the Union Beach Stormwater Management Plan.

- The large tracts of salt marsh at Conaskonk Point are the largest remaining salt marsh in the Raritan Point, on the northwest border of Union Beach. Two hundred (200) acres were acquired in 2000. Project proposal includes marsh restoration, replanting, and regrading of marsh and tidal channel.

Superstorm Sandy's Impacts to Union Beach

Prior to Superstorm Sandy there were 35 properties with repetitive loss claims in Union Beach and now the Borough has over 500 homes listed on the Severe Repetitive Loss and Repetitive Loss lists (T&M Associates, 2014). Superstorm Sandy's tidal surge and waves inundated 90% of the Borough's land area with 2-10 feet of water effected 2,043 housing units and the storm's wind, rains and surge caused extensive damage to bulkheads and property: 60 homes were destroyed, 143 severely damaged, 629 substantially damaged. Figure 3.9 shows the areas of Union Beach that were inundated by Superstorm Sandy's surge and Figure 3.10 shows the early FEMA damage assessments.

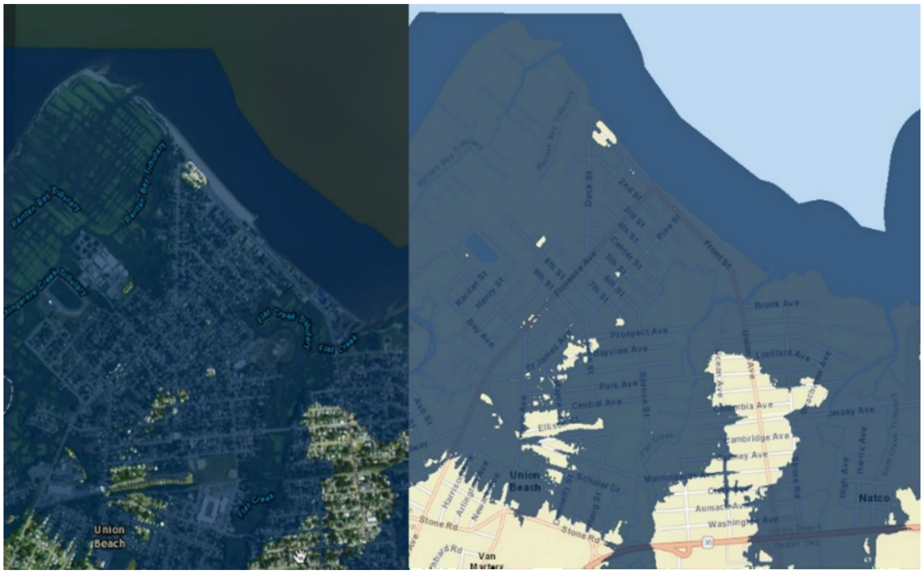

Figure 3.9 Extent of Superstorm Sandy's storm surge in Union Beach, New Jersey.
Source: Rutgers Floodmapper (2016) accessed June 25, 2016: http://slrviewer.rutgers.edu/

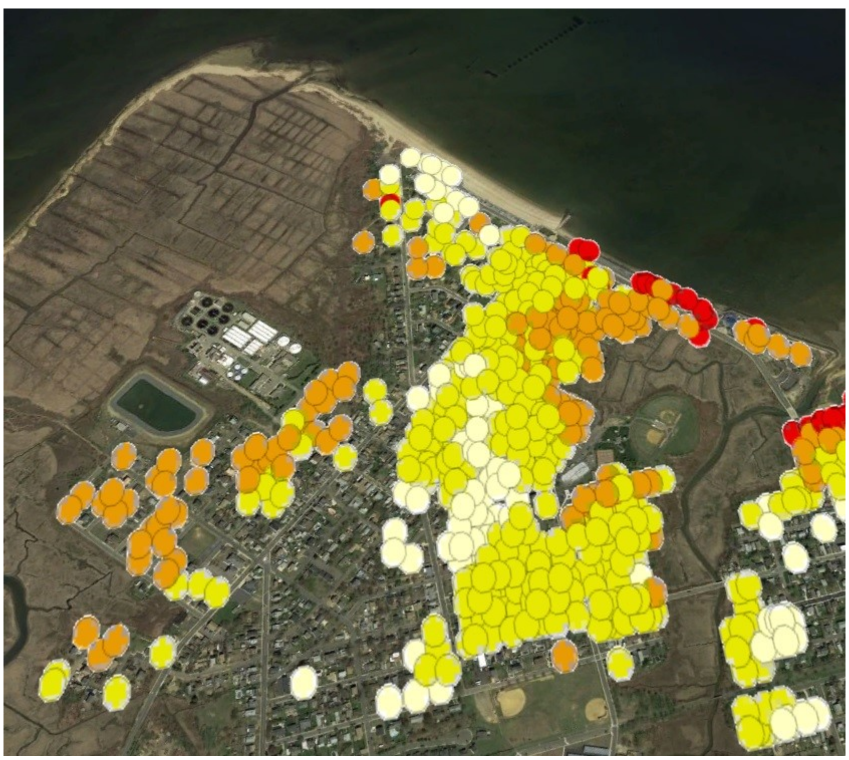

Figure 3.10 Damage assessment of Union Beach from Superstorm Sandy at the building level: represents damage classes derived from a combination of imagery-based assessments and flood depth. Tan ("affected"), Yellow ("minor"), Orange ("Major"), Red ("Destroyed"). Description of each assessment category is given in Figure 3.5.
Source accessed November 17, 2016:
http://services.femadata.com/arcgis/rest/services/2012_Sandy/Imagery_Based_PDA/MapServer/layers

3.4 Documented Public Response to Mitigation Strategies

During the development of plans and presentation of mitigation strategies, some public response has been documented. In 1960, the USACE published their findings for shore protection measures to mitigate erosion and hurricane storm effects in the Raritan and Sandy Hook Bay reach (USACE, 1960). The report documented that local interests desired protection against beach erosion and tidal flooding to include beach fill, bulkheads, silt deposit removal from mouth of Conaskonk Creek to facilitate drainage in Union Beach, and groins and offshore breakwaters at Point Comfort, Keansburg to protect fill. Local interests generally favored beach creation which was found to be economically feasible where beach berms could be provided to protect the shore from erosion and mitigate tidal flooding. The 1993 USACE reconnaissance study that investigated shoreline projects for Union Beach (Coastal Planning & Engineering et al., 1993) reported local interests were in repairing the bulkhead, development of a recreational beach and stone groin northwest of the bulkhead. There has since been no documentation of the finalized USACE mitigation project discussed above.

The NY/NJ Baykeeper organization has reported that property owners in the Borough have objected to proposed plans for berms in Union Beach because of potential obstruction of waterfront views (McCay et al., 2005). During community working groups in 2014 focused on resiliency, held as part of updating the Monmouth County Master Plan, participants identified opportunities for restoring living shorelines and using wetlands as buffers against storms and flooding. Weaknesses included stormwater infrastructure in need of repair and upstream development having downstream effects; and threats to include inconsistent implementation of resilient infrastructure and coastal subsidence exacerbating sea level rise (Monmouth County Planning Board, 2014).

The researcher is unaware of any local opinion and interest related to hazard mitigation infrastructure existing or proposed in the Laurence Harbor community other than local interest in the remediation of the Superfund site of which the existing engineered infrastructure is a part. Discussions include what to do with the structures, such as capping them. There is no discussion of enhancing them for the purposes of flood mitigation or erosion control.

3.5 Summary of Study Areas

Flooding in the two study areas is caused by bay surge as well as high tides, but is much more prevalent in Union Beach than Laurence Harbor. Shoreline erosion has eliminated much of the beachfronts in both areas and has resulted in deterioration of existing coastal mitigation and drainage structures. In both areas, especially Union Beach, the blockage of existing drainage systems and the clogging of wetlands and creeks has compounded the extent and duration of flooding. The flat gradient and low relief of the surrounding terrain in Union Beach makes it extremely vulnerable to flooding during heavy rainfall where creeks overtop and spread flood waters over a broad flood plain eliminating drainage of interior areas (Coastal Planning & Engineering et al., 1993). Along low-lying areas and due to the numerous creeks and waterways that the intersect the shoreline, normal high tides frequently flood Union Beach as a result of interior peak flows coinciding with high tides and/ or storm surge. Laurence Harbor also experienced some flooding during storm events from surge. Laurence Harbor has experienced erosion along the shoreline and erosion of the cliff.

CHAPTER 4

METHOD

To study the public perceptions of coastal hazard mitigation strategies, it is important to investigate in communities where coastal hazards and associated risk is salient to the public. Coastal hazards should be salient to residents living in communities that have experienced negative consequences of these hazards. It is the purpose of this research to explore how members of the public, as essential governance actors, perceive mitigation infrastructure. Therefore, the participants of the study are long term residents in coastal communities where risk from coastal hazards is manifest.

The purpose of this research is to explore what the public living in coastal areas thinks about natural and engineered infrastructure, both their function in mitigating coastal hazards and how the infrastructures might affect the other's functioning. This research is influenced by others' research and seeks knowledge of public perceptions that has not been investigated. Existing research does not present a cohesive view of how residents in at-risk coastal communities perceive both types of mitigation infrastructure.

This study seeks to answer a number of research questions in order to meet the research objectives. These research questions were answered by conducting face-to-face semi-structured interviews with a non-probabilistic, heterogeneous, purposive sample of residents in two coastal communities in the Raritan Bayshore region of New Jersey. Semi-structured interviewing was chosen as the research method because data collected this way fills a gap in knowledge that other methods, such as survey or questionnaire, are unable to bridge efficaciously (Dunn, 2010). Other methods can also be used to study a range of opinions, diversity of meanings and experiences, and uncover common themes among respondents, but interviewing allows the researcher to investigate the complex reasoning of interview participants. Interviewing can also engage and motivate participants in a way that other survey methods such as questionnaires cannot (Dunn, 2010). Interviewing encourages participants to provide more information than they otherwise might if filling out a questionnaire. In interviews, participants impart information the researcher has not considered or that has not been uncovered through previous research (and thus would not be captured in a survey instrument). Additionally, for a study where little is already known, such as this one, there is not enough existing information about public perceptions to construct options necessary for creating a structured questionnaire and an open-ended survey would not enable participants to ask questions about unfamiliar terms. Interviewing also allows the researcher to probe to uncover more from the participants. Semi-structured interviewing has a pre-determined order of questions, but allows more flexibility in the way issues are addressed by the participant then a survey or structured interviews would and allows the investigator and participant to request clarification of statements made or questions asked.

4.1 Inductive Content and Thematic Analysis

Content analysis is a method of analyzing written, verbal, or visual communication data, such as interview data, by attaining a condensed and broad description of phenomena (Elo et al., 2008). It is a systematic and objective means of describing data and can be used to quantify data. This method is often used to enhance understanding of interview data and to provide knowledge and new insights. As a research method, content analysis makes replicable and valid inferences from data to their context. There are two types of content analysis: inductive and deductive. In inductive content analysis, the method used in this research, concepts are derived from the data collected during the interviews. Conversely, in deductive analysis, the structure of analysis is based on prior knowledge or frameworks and used to test a theory. Since there is limited research and no pre-existing theories about perceptions of the functions of and relationships between mitigation infrastructures, inductive content analysis was chosen for this study.

Thematic analysis is a method of identifying, analyzing, and deciphering patterns (or themes) within the data relevant to the research questions (Braun et al., 2006). Inductive, thematic analysis of content from interviews is different from other qualitative methods, such as discourse analysis or grounded theory, which are bounded by conceptual parameters. The thematic approach allows for themes to be identified without losing details of the accounts given by the participants. The phases of thematic analysis include organizing the data through open coding and grouping into categorizes and then abstracting the relationships among the relevant categorizes. Coding also helps to connect empirical findings to that of the literature (Cope, 2010).

The outcome of thematic, content analysis is a series of categories that describe the phenomenon of local residents' perceptions and awareness regarding the functions of and relationships between mitigation infrastructures. The aim is a condensed and broad description of the phenomenon of local public perception of mitigation infrastructure in coastal areas where risk is salient and where mitigation infrastructures exist. In this method, themes are derived from the manifest data of interview notes and coding sheets.

A number of similar research studies have used coding and thematic content analysis to investigate the public perceptions of coastal hazard risk or mitigation strategies. Bethel, et al. (2011) examined local communities' knowledge and awareness of the value of coastal wetlands by analyzing interview data through inductive coding and the resultant creation of themes to identify underlying concepts. Both Santha, et al. (2014) and Couling (2014) analyzed data from semi-structured interviews and other participatory techniques using thematic content analysis. Santha et al. (2014) demonstrated that residents in fishing villages in India perceived engineered interventions to have exacerbated risk from coastal hazards by producing a map relating the major themes of local knowledge, risk perception and perception of risk reduction measures. Couling (2014), by using thematic content analysis, provided a detailed account of local knowledge, risk perception and emergency preparedness by discovering common themes in the interview data.

Thematic analysis has also been carried out using grounded theory where the codes are pre-determined based on a conceptual framework. Both Kane et al. (2014) and Touili et al. (2014) used existing risk perception frameworks to analyze interview data and through this analysis the researchers were able to uncover emergent themes that did not fall into the pre-determined categories. Lopez-Marrero (2010) also categorized interview data by using pre-determined codes based on theories of adaptive capacity and analyzed the data by counting the number of times certain responses were given. She described residents' experiences of changing conditions brought on by hazard events and their perception of the efficacy of strategies for coastal hazard protection, flood risk, and barriers to implementation. Similar to Lopez-Marrero, Mustelin et al. (2010) quantified the number of responses given and organized them by their research questions. They were able to determine general trends in perceptions in their study areas and identify connections between the perceptions of environmental change and coastal hazards and preference for mitigation interventions.

Thematic content analysis is a useful method to systematically describe perceptions of risk and mitigation infrastructure. This analysis technique has been chosen to describe public perceptions of the role of and relationship between engineered and natural mitigation infrastructure since other researchers have used it successfully to describe public perceptions of coastal hazards, risk and mitigation options.

The data analysis method used emergent coding, not pre-determined codes from other research studies, since there is no other research that investigated the perception of the relationship between different types of mitigation infrastructure. The findings of this research are presented through descriptive analysis of the data based on the coding. The coding allows for comparison of the findings to that of other empirical studies.

4.2 Recruitment of Participants

Participants in the research study are long-term residents living in the communities of Laurence Harbor, (Old Bridge Township), Middlesex County, New Jersey and Union Beach, Monmouth County, New Jersey. Residence in the area for more than 5 years was chosen as a parameter for qualification in this study to ensure that participants had experience with at least two recent storm events. The researcher attempted to recruit, through purposive sampling, a range of ages, approximate equal representation of both genders as well as residents in different parts of the respective towns because location of one's residence relative to the coastline and areas prone to flooding may influence perception of coastal hazards and mitigation infrastructure.

Participants were recruited through community organizations, local libraries, community events, and word-of mouth. Flyers were posted at the local libraries and shared through community organizations. Most of the recruitment occurred through a few active community members and then through word of mouth and recommendation. For example, in Union Beach, recruitment was assisted through contacts of a pastor, an active post-Sandy volunteer, and the local librarian. Similarly, in Laurence Harbor, once contact was made with a few long-term residents those residents shared the researcher's contact information and flyers with neighbors and friends. It was through the word-of-mouth that the researcher was able to target residents in certain areas of town and seek wider demographic representation. The goal was twelve (12) to fifteen (15) participants per study area. Recruitment of participants ended after the researcher had interviewed at least twelve participants with a good balance of both genders with a spread of age and residential location and when she was not hearing anything new in the interviews.

During recruitment, residents were briefly introduced to the research purpose and its significance and informed that they were being asked to voluntarily participate in an interview that would last approximately one hour. After each participant agreed to participate, the interview was scheduled at a location of convenience for the participant either at the resident's home or a local community gathering place such as the library. A few of the Laurence Harbor interviews were conducted at a local pizza restaurant.

Ethical Consideration

The study was approved by the New Jersey Institute of Technology (NJIT) Institutional Review Board (IRB) in August 2015. The project approval was based on the researcher's application to the council and resultant meeting. The IRB application process reviewed the procedures that would be used for recruitment, as discussed above, addressed the benefits of the research, and the procedure the researcher would use to gain informed consent from residents to participate. The IRB approval is included in the Appendix.

There were no attendant risks to the study participants from participating in the interviews. Participants were made aware that none of their personal information would be used in any written material nor in the maintenance of the data records. Each participant was given a unique identifier that was used in all of the paper and electronic data records maintained by the researcher. During the interview, demographic information was collected. No personal information was solicited from participants that would be harmful to them if revealed.

4.3 Research Design

One semi-structured interview was conducted with each participant. The research method was designed to reduce bias in the information received. Since one of the goals of the research is to understand coastal residents' awareness of engineered and natural mitigation infrastructure, it was important to only conduct one interview. Holding one interview helped to reduce bias in the data by helping to minimize influence on the participants. The process of participating in an interview on complex topics that most people do not concern themselves with on a daily basis will, in itself, raise awareness of the topic. The act of participating in an interview and in-depth discussion on such complex topics will challenge the participants to think more about the general subject. Therefore, if a second interview was held, much of the information received would be how the participant has come to think *more* about the relevant set of issues. Although valuable for additional research investigation, it was not the purpose of this study to investigate the learning process associated with comprehending mitigation infrastructure or to conduct a longitudinal study to see how opinions and perceptions change over time.

Since this was the first study to investigate the specific research questions, it was an exploratory investigation. The aim was not to have samples that were statistically representative of the communities and to have at least twelve participants with a mix of age, gender, and from multiple locations in town. The sampling was deliberate and not completely random nor solely based on who volunteered or was available: a type of purposive sampling (Babbie, 2013) based on the goal of two study samples with residents with some demographic mix.

4.3.1 Interview Process

Before beginning each interview, the researcher reviewed the IRB-approved Consent Form with each participant including: permission to audio record the interview, review of the confidentiality of their names and associated residence location, description of the interview process including the use of photographs from the region and disclosure that the information collected from the interviews would be used for a dissertation. All participants consented to the interview and understood the terms of the interview process and use of the data.

The interviews began with brief demographic questions: participant's age, length of time residing in the area, previous residence, and approximate location of residence on a map, occupation and educational background. Participants were also asked if they intended to continue to live in the area. The demographic and background questions do not serve to address the research questions: they are important to give context to the research findings. These questions give perspective on how experience living in the area, both duration and the location of the participant's residence, may affect perception of coastal hazards and mitigation infrastructures. The general location of participants' residences and their spatial relation to the location of the mitigation infrastructures can be seen on the maps provided in Section 4.4.

At the commencement of each interview, the researcher re-introduced the purpose and subject of the study to the participant and answered any questions the participant might have had. The researcher explained that the participant would be asked about physical features in the areas, both human-built structures and natural, environmental features that serve to reduce coastal hazards or impact from coastal hazards and what they think about these features. Coastal hazards were described to the participants as coastal storms and their associated wind and wave energy and storm surge, coastal flooding, and coastal erosion. The goal of the study was to understand the preconceived perceptions of residents without bias. Therefore, a limited introduction to the study was given and although the participants were asked to share any additional information at the end of the interview, their responses were not summarized for them, nor were they given a chance to correct or change their responses.

The interviews lasted on average one hour and followed the Interview Schedule with probing as needed. Examples of probing included explaining a question or asking for participants to elaborate on an answer. The researcher used a coding sheet to make notes during the interview. The coding sheets used for each interview listed the interview questions verbatim in a matrix with space for hand-written notes and potential codes[20] for responses that were pre-determined from pre-test interviews. The Interview Schedule is contained in the Coding Sheet (Appendix C). During the interviews, photos were used for specific questions. As photos were referred to, they were noted in the researcher's interview notes as they were discussed to correspond to location in interview transcript.

As participants responded to each question, the interviewer took notes on the coding sheet. In addition to the responses given for each question, participants were given the opportunity to make additional comments at the end of the interview. These comments were recorded on the interview coding sheets.

4.3.2 Interview Content

The interview questions were developed to elicit any relevant information that study participants could provide to address the research questions about residents' awareness and perceptions of mitigation infrastructure, information that they use to form their perceptions, and their preferences for the use of certain mitigation infrastructure in the future.

The interview questions, informed by the findings of other research studies, were designed to address the research questions and meet the research objectives. Researchers studying European and Mediterranean coastal areas have found that diverse groups of

[20] Coding is assigning interpretative tags to interview responses based on categories or themes (Cope, 2010). It is helpful in evaluating and organizing data to elicit meaning and make sense of the data in a more rigorous way.

stakeholders do perceive the costs and benefits and redistributive effects of engineered infrastructure (Kane et al., 2014; Touili et al., 2014) and that perception of benefits such as improving the visual quality of a coastal area as well as perceptions of strategies working better to reduce impact from hazards influence preference (Koutrakis et al., 2011). Kane et al. and Touli et al. studied the same areas: three European coastal areas that are the subject of a consortium effort to design more sustainable coastal protection strategies and used the same participants: stakeholders that have been involved in the governance process. Although Kane et al. and Touli et al. and Koutrakis et al.'s studies were in areas facing the same coastal hazards: flooding and erosion, they had different coastal risk settings. Koutrakis et al. surveyed a different type of stakeholder than Kane et al. and Touli et al: beach users mostly day tourists. Koutrakis et al.'s study was conducted in five Mediterranean locations all prone to erosion, with different social-economic and physical characteristics, and mitigation strategies. Although these European study areas are equally diverse among themselves as they are to the study areas in this research, the findings from these studies helped frame the questions for this study. The interview instrument for this study was informed by the findings of these previous studies: a key stakeholder group, residents, in this case, from the U.S. State of New Jersey, were asked about the costs and benefits of, the relationship between, and their preference for mitigation infrastructure. Residents were also asked about their understanding of the relationship between engineered and natural infrastructure and if they perceived an advantage or disadvantage of the structures and features on the other: a way to investigate if the participants in this study, similar to the findings of Touli et al. (2014), consider that engineered infrastructure may displace impact of hazards, such as displacing flood waters or causing erosion elsewhere.

The interview schedule was organized into three sections. The first series of questions asked about participants' awareness of existing natural and engineered infrastructure that might exist in their community to reduce coastal hazards or impact from coastal hazards. The second series of questions were accompanied by photographs of engineered structures and natural features in the participants' town and asked about their perceptions of the structures and features individually and as groups (types of infrastructure: engineered and natural). During the first two sets of questions relating to existing infrastructure, participants were first asked about engineered structures then natural features. The third series of questions asked about participants' preferences for the use of mitigation infrastructure.

The interview questions and schedule were pre-tested with six (6) residents in other coastal areas in New Jersey. The purpose of the pre-test was to get feedback from the lay public on terminology used in the interview, the flow of the interview questions, and the interview process in general as well as to design the coding sheet that would be used in the formal interviews. The pre-testing of the interview questions was useful to determine the best wording of the interview questions and to get feedback from pre-test participants on the interview process. Pre-test participants were asked, after responding to all of the interview questions, if they had understood the questions, if they had suggestions for a better way to frame questions, and if they had any suggestions for the interview process. Suggestions on how to probe or explain questions were also received through the pre-test process. These considerations were helpful in finalizing the interview schedule for the study and in developing the coding sheets and potential codes associated with each question.

During the first series of interview questions, participants were asked about their awareness of existing mitigation infrastructure: those built structures or natural features that might exist to reduce coastal hazards or impact from coastal hazards. These questions sought to uncover which built structures and natural features participants are aware of: the structures and features the participants first thought of and could describe. During the second series of questions, participants were shown photographs of built structures and natural features in their town. (Figures 4.1 and 4.2 show the photographs used during the interviews and their location, respectively.) Participants were asked what they thought of the structures and features shown in the photographs. Participants were not led to reply that any of the structures or features shown in the pictures are helpful in mitigating hazards. They were able to offer their thoughts about the structures and features when first shown the picture, being asked "What can you tell me about this structure/ feature associated with coastal hazards?" And then asked whether they thought the structures/ features reduces particular coastal hazards and impacts of storms, flooding, and erosion by being asked "Do you think this structure/ feature reduces [given hazard] or impact from [given hazard]?"

The same photographs were then grouped into natural features and built structures and questions were asked about them as a group (mitigation infrastructures). Participants were asked to compare the infrastructures (if they perceived one type to have more benefit or lower cost), they were asked about their perception of the relationship between the infrastructures and if they perceived a conflict between them, and which type of infrastructure they perceive as better for their area.

Figure 4.1 Photographs of engineered structures and natural features from Laurence Harbor (1) and Union Beach (2). Laurence Harbor: 1A: Stone revetment; 1B: Second groin; 1C: Dune area on beach near Marquis Creek; 1D: Wetland of Marquis Creek south west of Route 35; and Union Beach: 2A: Revetment and bulkhead; 2B: Groin; 2C: Wetland of Flat Creek; 2D: Maritime forest/ dune areas at Conaskonk Point. Photos A and B represent engineered infrastructure and photos C and D represent natural infrastructure. *Source: Taken by researcher on August 8, 2015*

Figure 4.2 Location of engineered structures and natural features (shown in Figure 4.1) from two study areas, Laurence Harbor (1) and Union Beach (2). Laurence Harbor: 1A: Stone revetment; 1B: Groin; 1C: Dune area; 1D: Wetland; and Union Beach: 2A: Revetment and bulkhead; 2B: Groin; 2C: Wetland; 2D: Maritime forest/ dune area.
Source of aerial: Google Maps, 2015

The last group of questions asked residents about coastal hazard mitigation projects for the future. They were asked if they knew about any proposals or planned projects to construct or enhance engineered or natural infrastructure for the purposes of reducing coastal hazards or impact from coastal hazards and what they would prefer be used in their community to mitigate the impact from coastal hazards.

The full interview guide with the order of the interview questions is provided in Appendix C as part of the coding sheet example.

A number of interview questions sought to address each specific research question. Therefore, there were multiple opportunities throughout the interview for the participants' responses to address the research questions. For example, there were a few interview questions that sought to identify participants' perception of the relationship between natural and engineered infrastructure. Participants were first asked if they believed that the infrastructures affect each other related to coastal hazards and a second series of questions asked whether participants believed that there was beneficial effect of the infrastructures on the other. As one example, with these two series of questions, participants were given multiple chances to describe how they perceive the features and structures working. And, from these two lines of questioning, the researcher was able to identify what the participants thought about the relationship between natural and engineered infrastructure. Table 4.1 shows which interview questions address specific research questions and research objectives.

Table 4.1 Interview Questions that Address Research Objectives and Specific Research Questions (Continued)

Research Objective	**Specific Research Question**	**Interview Questions that Seek to Address Research Question**
Explore coastal residents' **awareness** of natural and engineered infrastructure in mitigating coastal hazards.	How aware are coastal residents of natural and engineered mitigation infrastructure?	Do you know about any human-built structures along or near the coast that (are designed/ serve to) reduce coastal hazards or impact from coastal hazards to [Laurence Harbor/ Union Beach]? (If yes) Please describe one human-built coastal project or structure.
		How did you become aware of [human-built structures you mentioned]?
		Do you know about any natural environmental feature along or near the coast that reduce hazards or damage from coastal hazards in [Laurence Harbor/ Union Beach]?
		How did you become aware of [natural, environmental features you mentioned]?
		How did you become aware of this [built structure/ natural feature shown in the picture]?
	Are coastal residents aware of planned projects or proposals to fix, build or enhance engineered or natural mitigation infrastructure?	Do you know about any proposals to build coastal structures in [Laurence Harbor/ Union Beach] for purposes of reducing impact from hazards from storms, flooding or erosion?
		Do you know about any proposals to enhance natural environmental features in [Laurence Harbor/ Union Beach] for the purposes of reducing impact from storms, flooding or erosion we have been discussing?
	How do coastal residents become aware of/ learn about mitigation infrastructure?	How did you become aware of [the project(s) you mentioned]?
		Were you involved in [mentioned] project(s) planning or community discussions?

Table 4.1 (Continued) Interview Questions that Address Research Objectives and Specific Research Questions

Research Objective	**Specific Research Question**	**Interview Questions that Seek to Address Research Question**
Assess the coastal residents' **perceptions** of the role of and relationship between natural and engineered infrastructure in coastal hazard mitigation.	What do coastal residents perceive to be the functions of mitigation infrastructure?	What can you tell me about this [built structure/ natural feature shown in the picture]?
	What do coastal residents perceive to be the role of natural and engineered infrastructure in mitigating coastal hazards or impact from coastal hazards?	Do you think this [built structure/ natural feature shown in the picture] reduces hazards or impact to [LH/UB] from coastal storms?
		Do you think this [built structure/ natural feature shown in the picture] reduces coastal flooding or impacts from coastal flooding?
		Do you think this [built structure/ natural feature shown in the picture] reduces coastal erosion?
	What do coastal residents perceive to be the benefits and costs of mitigation infrastructure?	Do you think this [built structure/ natural feature shown in the picture] has any benefits not related to coastal hazards?
		Do you think this [built structure/ natural feature shown in the picture] creates any problems?
		Do you think that between natural features and built structures one is better than the other for [Laurence Harbor/ Union Beach]?
		Do you think one [between natural features and built structures] is better at reducing impact from coastal hazards? How?
		Do you think one [between natural features and built structures] is less costly? Why?

Table 4.1 (Continued) Interview Questions that Address Research Objectives and Specific Research Questions

Research Objective	**Specific Research Question**	**Interview Questions that Seek to Address Research Question**
Assess the coastal residents' **perceptions** of the role of and relationship between natural and engineered infrastructure in coastal hazard mitigation.	What do coastal residents perceive to be the benefits and costs of mitigation infrastructure?	Do you think one [between natural features and built structures] has more long-term benefits? What are they?
		Do you think one [between natural features and built structures] is easier to maintain? Explain.
		What do you think of the [planned/ proposed] projects [mentioned]?
		Why do you prefer [the projects of features you said you prefer be used to reduce coastal hazards or impact from coastal hazards]?
		If the features you prefer were built or enhanced, would they make [Laurence Harbor/ Union Beach] better? In what way?
	Do coastal residents perceive a relationship between natural and engineered infrastructure associated with coastal hazards?	Do you think that these two types [groups] of physical features [built structures and natural features] affect each other? That is, do they function differently when they are located near each other?
		Do you think that both natural environmental features and human-built structures could be used in [Laurence Harbor/ Union Beach] to reduce coastal hazards or impact from coastal hazards?

Table 4.1 (Continued) Interview Questions that Address Research Objectives and Specific Research Questions

Research Objective	**Specific Research Question**	**Interview Questions that Seek to Address Research Question**
Assess the coastal residents' **perceptions** of the role of and relationship between natural and engineered infrastructure in coastal hazard mitigation.	What do coastal residents perceive to be the relationship between mitigation infrastructures associated with coastal hazards?	[If so] How do you think they affect each other? (Probe: Do you think that these features work together/ enhance each other, work against/ contradict each other, or work separately/ independently during a storm?)
		How do you think they affect each other during a storm?
		How do you think they affect each other when there is flooding?
		How do you think they affect each other related to erosion?
		Do you think there is an advantage (or disadvantage) to the built structures by enhancing natural environmental features? (Probe: If there were more of these natural features, do you think there is a benefit (or detriment) to these built structures?)
		Do you think there is an advantage (or disadvantage) to the natural environmental features by enhancing built structures? (Probe: If there were more of these built structures, do you think there is a benefit (or detriment) to these natural features?)
	What do coastal residents think about planned projects or proposals to fix, build, or enhance mitigation infrastructure?	What do you think about [mentioned proposals to build coastal structures or enhance natural environmental features]?

Table 4.1 (Continued) Interview Questions that Address Research Objectives and Specific Research Questions

Research Objective	**Specific Research Question**	**Interview Questions that Seek to Address Research Question**
Uncover the coastal residents' **preference** for their communities as it relates to the use of natural and engineered infrastructures.	What types of mitigation infrastructure do coastal residents prefer be used for their area?	Do you think that both natural environmental features and human-built structures should be used in [Laurence Harbor/ Union Beach] to reduce coastal hazards or impact from coastal hazards?
		Thinking about the future, are there any projects or features you would prefer be used to reduce coastal hazards or impact from coastal hazards in [Laurence Harbor/ Union Beach]? What would you prefer?
		Any existing coastal features you believe should be enhanced for reducing coastal hazards or impact from coastal hazards?
		Are there natural features or built coastal structures not here now that you would like to see for [Laurence Harbor/ Union Beach] for purposes of reducing coastal hazards or impact from coastal hazards? Can you describe these?

4.4 Data Collection and Management

Data from each interview was electronically recorded on coding sheets using the hand written notes and audio recordings from the interview and given a unique identifier. There was no personally-identifiable information about individual participants retained in the researcher's records.

4.4.1 The Participants

There were fourteen (14) participants from Laurence Harbor and thirteen (13) from Union Beach representing a range of age, gender, and length of residence. The two samples were slightly skewed in age range: 31% of the Union Beach residents were older than 75 years and 21% of the participants from Laurence Harbor were between 24-35 years. Within the study groups, there was a good range of ages represented. Figure 4.3 presents the demographics of the study participants from both study areas.

Although not recruited based on educational background, participants also had a range of educational attainment and occupation. Twenty-six percent (26%) of participants had completed only high school, 22% some college, 33% had a college degree, and 19% a graduate degree. Occupations included social work/education, science/medicine, business and one person in the arts.

Participants gave a number of reasons for living in the area and most intend to stay. The most commonly heard reason for living in Laurence Harbor was being in a coastal area and the water. And, in Union Beach, most study participants gave their reason for living there as family and community, as well as affordability. Laurence Harbor residents also mentioned the convenience and access to their job as well as activities. Approximately half of the participants in Laurence Harbor have lived in other parts of the town, while only two participants in Union Beach have lived in a different part of town.

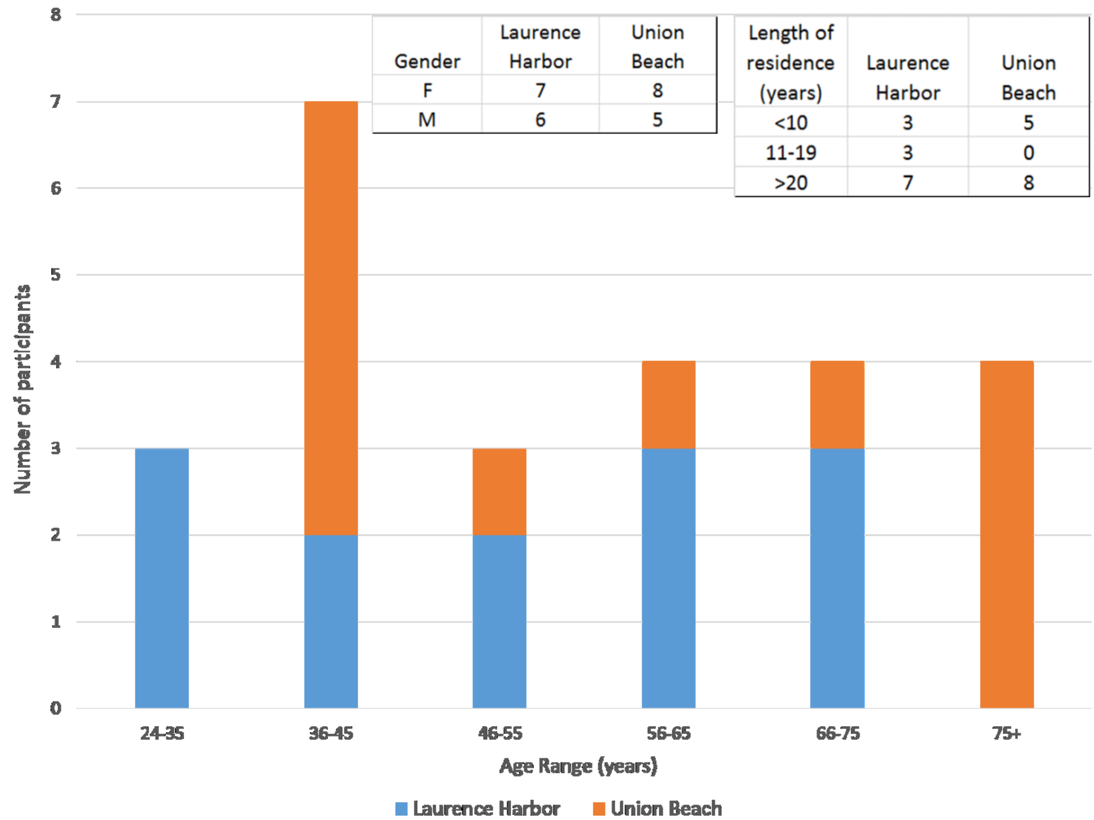

Figure 4.3 Age and gender of study participants and length of residence.

The approximate location of the participants' residences is shown in Figure 4.4. Although not asked about damages or impacts to their properties from Sandy, comparison of the maps of resident location with those of Sandy storm surge inundation (Figures 3.4 and 3.6) shows that all of Union Beach participants live in areas that were flooded during Sandy, unlike Laurence Harbor, where only a few live in areas that were impacted by flood waters.

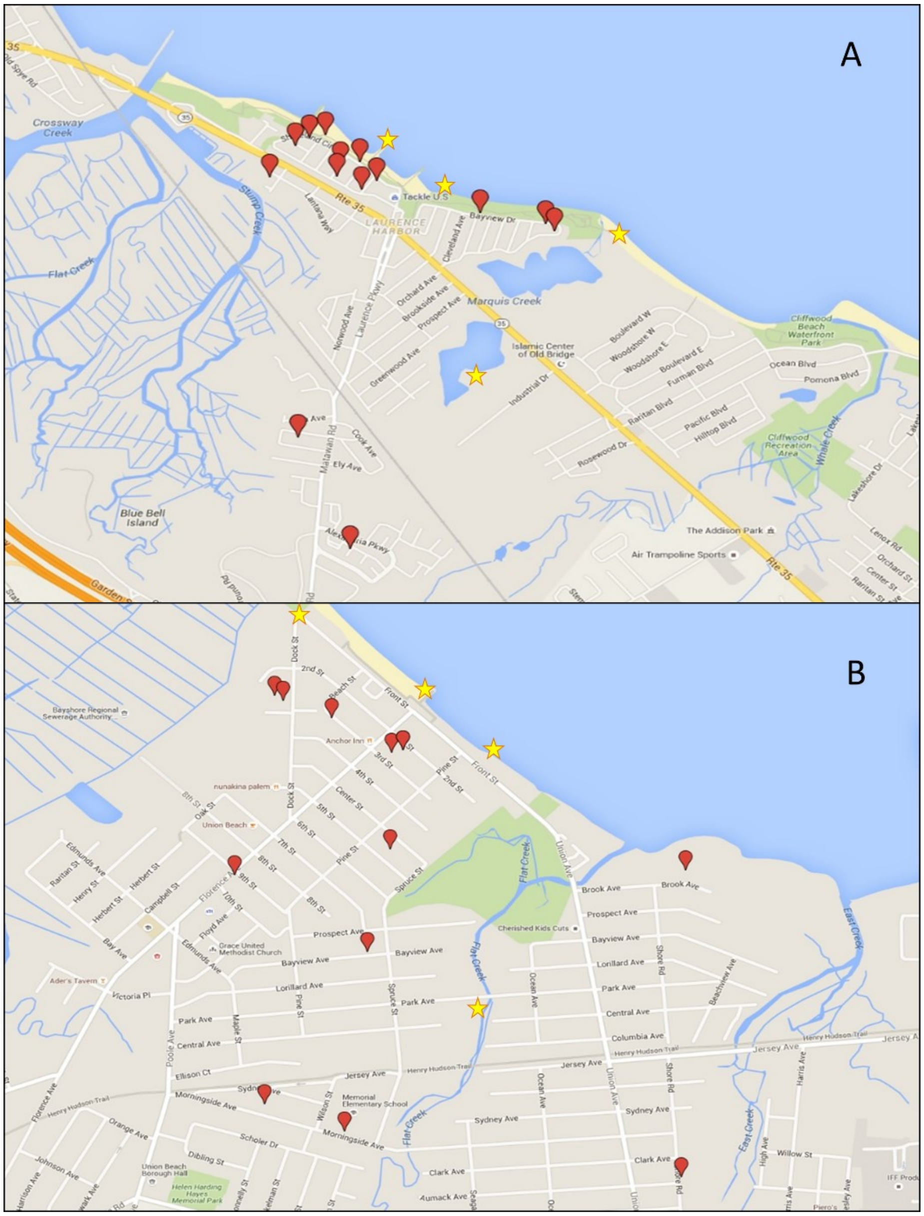

Figure 4.4 The geographic distribution of the study participants' residences (red pin): A: Laurence Harbor; B: Union Beach. Also shown on these maps are the location of the mitigation infrastructures shown in pictures and discussed during the interviews (yellow stars). *Map source: Google Maps, 2015*

4.4.2 Data Collection and Preparation

During interviews, which were audio recorded, responses, interviewer notes, and preliminary codes for responses to questions were demarked on a printed coding sheets by the interviewer. Preliminary codes were identified from pre-test responses and were chosen to represent a range of responses. For example, during the questions on the relationship between infrastructures, the coding sheet had a range of possible answers that might be expected based on the pre-test findings: the structures/ features negate, conflict or contradict each other's function, enhance or support each other's function, work separately (do not affect the other's function). As with most of the questions, a possible code was "unsure".

There are three main steps taken during content analysis: Preparation, Organization and Reporting (Elo et al., 2008). Figure 4.5 shows the steps taken for data preparation, organization, and reporting.

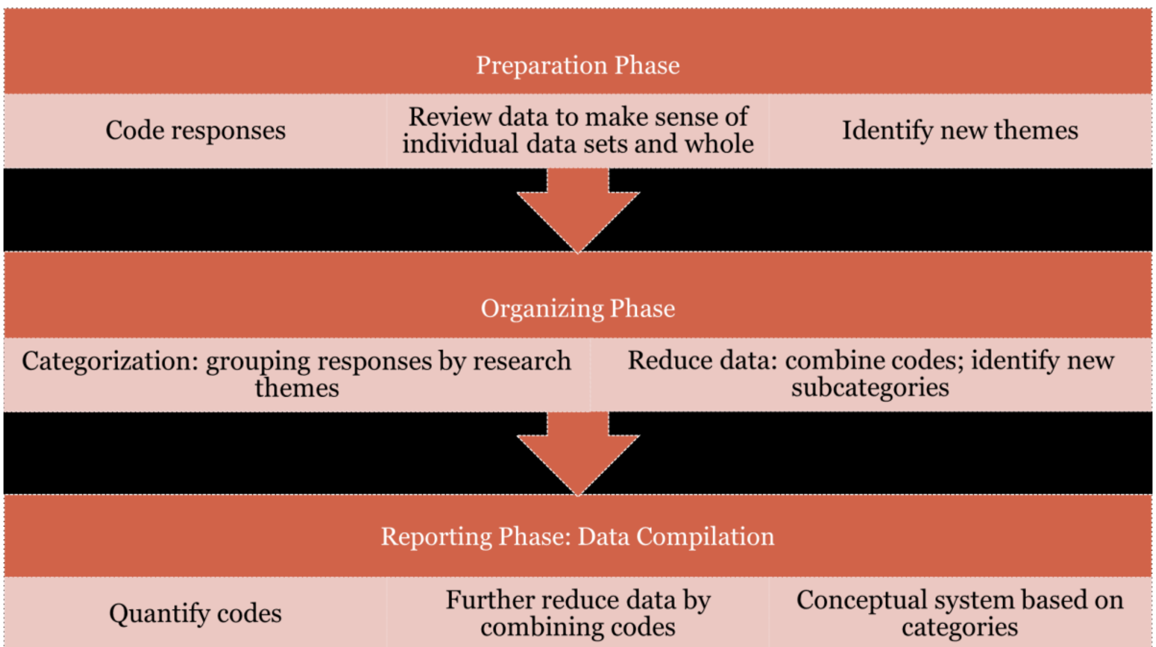

Figure 4.5 An overview of the steps taken for data preparation, organization and analysis.

During the Preparation Phase, raw data (hand-written notes and identified codes) from each interview coding sheet was transferred electronically onto an Individual Coding Sheet for each participant. The interviewer then used the audio recordings of each interview to add any information provided during the interviews that may not have been recorded in the hand-written notes taken on the coding sheet during the interviews. During this phase, notes were also made by the researcher clarifying what was said by the participant during the interview or where probing was needed.

Table 4.2 The Categories and Sub-Categories (right-justified) Used to Organize the Raw Data on the Individual Data Analysis Sheets

Category	**Meaning/ Description of category**
Awareness of mitigation infrastructure and proposed projects	Are residents conscious of existing mitigation infrastructures? Are residents aware of proposals to enhance or create mitigation infrastructure?
Source of awareness	How have residents come to be aware of the structures and features either offered or shown in pictures?
Perception of mitigation infrastructure (for each structure and feature shown in pictures)	What do residents know and think about the existing individual structures and features in their area associated with coastal hazards?
Function associated with specific coastal hazards	What do residents think about each structure and feature shown related to coastal hazards? (Both offered, before prompting and after asked about specific hazards.)
Relationship	Do residents perceive a relationship between infrastructures associated with coastal hazards?
Overarching function of infrastructures	What do residents know and think about the functions of existing mitigation structures and features as groups of engineered and natural infrastructure?
Benefits/ costs	To residents perceive a lower cost, lower maintenance, long-term benefits of existing infrastructures? What do residents think are the benefits or problems associated with the individual structures/ features not associated with coastal hazards?
Preference	What do they prefer be used to mitigate coastal hazards?
Perception associated with preference	Why do residents prefer certain structures or features be used to mitigate coastal hazards? What do they think about the proposals they know about?

During the Organizing Phase, the "raw" data from each of the Individual Coding Sheets were transferred to Individual Data Analysis Sheets. Individual Data Analysis

Sheets grouped the responses to interview questions by research question category: awareness of mitigation infrastructures, perception of both infrastructures individually and in relation to each other's functioning, and preference for the use of mitigation infrastructures. Table 4.2 shows the categories in which the data from the Individual Coding Sheets were organized on each Individual Data Analysis Sheet. The Table also explains what information these categories provide.

The data were then reduced on the Individual Data Analysis Sheets, where the best codes based on themes of responses were identified. Credibility of the research findings is dependent on how well the categories cover all the data (Elo et al., 2008). During the transfer of the raw data to the Individual Data Analysis Sheets, new codes were identified. These were often descriptions of how a structure or feature worked, if offered. Explanation of how a structure or feature worked was also given during responses to questions on if the participants thought a structure or feature played a role in reducing certain coastal hazards. These responses were included as sub-categories. The codes in these subcategories represent explanation or clarification of an answer to an interview question. For example, in the category of the function of infrastructures related to reducing hazards, participants often offered how they perceived a specific structure or natural feature to work: this is a subcategory. The subcodes are clarifiers to responses that participants gave as further explanation or caveats to their initial response to an interview question. For example, where a participant stated that a structure or feature reduces impact from storms and conditioned that its ability to do so is "dependent on the storm", "reduce hazard" is the code and "depends" is a clarifier of sub-code. Another example of a clarifier is where a response is followed up with statements such as "this happens sometimes" or that reduction of impact from a hazard is “minimal”. During the Organization Phase, data were further organized where responses that were given to one question but that were answering a different research question were moved to the category for that research question. During the Organization Phase responses were excluded if they did not address the research questions and pertain to engineered or natural infrastructure. For example, structural interventions that may reduce risk such as road or house raising are not considered engineered infrastructure and were not included in the data for analysis.

4.4.3 Reliability and Validity of the Data

The validity and trustworthiness of the data are ensured through the detailed description of the analysis process and by identifying the strengths and weaknesses of the method (Elo et al., 2008). The limitation of thematic content analysis is that the researcher has the active role in identifying which themes are explored and reported (Couling, 2014). Researcher bias has been minimized by the inclusion of descriptive data in the discussion of the results, demonstrating themes in context of all the findings from the participants. To minimize bias in the information received from the study participants, only one interview was conducted.

The integrity of individual data was retained during the analysis by assuring the data were not compressed too much or excessively interpreted when combining into the full study area data set. To further ensure the quality of the data and analysis, the research questions were kept in mind during the content analysis, especially through organization of the data into categories of the research questions as well as removing irrelevant information from the analysis. To ensure transferability of the research method, a clear description of the context, selection, and characteristics of the participants, data collection, and process of analysis is presented.

4.5 Data Analysis

The Preparation and Organization of the data prepared the researcher for the Reporting Phase. During the Reporting Phase, all the data sets for each study area were combined onto a single Data Compilation Sheet for each study area. The demographics and background of the participants were also summarized (provided in Section 4.4.1). Selective narrative responses and quotes from the Individual Data Analysis Sheets were included in a column for each category. Themes from each of the interviews were summarized and common themes identified. Summaries of each individual data set (for each participant) were also made during the Reporting Phase.

During the Reporting Phase, sub-categories were created where supporting information that helps to describe responses or clarify codes were captured. These data were not expected or prompted: they are examples of explanation offered by the participants for answers they gave to an interview question. The researcher did not probe for these responses. Since these responses are relevant to the research goals, they were reflected in sub-categories. For example, participants may have offered how they thought a particular structure or feature functions as a clarification of their response that a feature or structure reduced impact from storms. These responses were captured in a subcategory of participants' perception of "how" a structure/ feature functions. Examples of codes for these subcategories are "redirects water", "breaks waves" or "being a place for water to go".

The emergent codes and subcodes identified in each of the Individual Analysis Sheets were quantified on the Data Compilation Sheets to assist in the analysis. Where possible, codes were combined to further reduce the data. The codes used and those that were combined during data reduction are shown in Table 4.3. The table presents those codes that were selected during data reduction, their associated meaning, equivalent phases, and the codes that were combined during data reduction.

Table 4.3 Codes used for the data reduction during the Data Compilation and their equivalent meanings (Continued)

Code/ Meaning Units (associated with certain categories)	**Other terms/ phrases of equivalency/ meaning**
Studied (source of awareness)	Investigated; asked about; sought out more information
See it (source of awareness)	Experience; watched it; grew up playing on it; observation; live by it; walking by/ through
Government (source of awareness)	Town council meeting; town bulletin, public notices
Support (relationship between infrastructures)	Reinforce; function/ work together; includes "doing the same thing"; supplement what the other cannot do; enhance; make better; protect the other; enhance
Contradict (relationship between infrastructures)	Negate; conflict
Reduces erosion (function)	Holds sand/ sediment; collects sand; keeps water from taking sand away; builds up sand; stop erosion; protect against erosion; retains sediment; anchor soil/ sediment
Doesn’t reduce hazard or impact from hazard (function)	Doesn’t make a difference; doesn't do anything; doesn't protect area
Increases flooding (function)	Overflows a lot
Increases erosion (function)	More sand to wash away

Table 4.3 (Continued) Codes used for the data reduction during the Data Compilation and their equivalent meanings

Code/ Meaning Units (associated with certain categories)	Other terms/ phrases of equivalency/ meaning
Redirects water (function)	Stops water from going in one direction; breaks way water flows; change direction of water; disperse water; artery for water; modifies direction of water; changes movement of water;
Breaks waves/ water (function)	Reduce/ minimize storm surge; breaks up waves; slows down water; reduces energy of waves; dissipate energy of waves; mitigates wave action; breaks up surge; absorbs tidal surge; slow down water; mitigate wave action; reduce velocity of water
Place for water to go (function)	Absorb water; acts like a sponge; catch basin; water goes to creeks; catchment; suck up water; hold water
Contains water (function)	Holds water back; Traps water behind it; keeps water back; water cannot go anywhere
Buffer (function)	Reduce wind; trees deter energy; dissipate energy storm; cuts down wind; slows flooding; barrier; keeps water away; blocks water; keeps water back; blocks wind; dissipate energy; buffer wind; blocks off conduits; reduce energy; protects against wind and water
Keeps sand (function)	Collects sand; keeps water from taking sand away; protects grasses; root ground; plants prevent erosion; allows soil to be built back up; plants may prevent erosion from wind and precipitation
Self-maintaining (benefits)	Replenish over time; grows back; comes back on own; self-repairing
Maintenance (perception of cost)	Self-maintaining, has to be repaired
No maintenance (perception of cost)	Don’t have to do anything

Table 4.3 (Continued) Codes used for the data reduction during the Data Compilation and their equivalent meanings

Code/ Meaning Units (associated with certain categories)	Other terms/ phrases of equivalency/ meaning
Designed to [reduce hazard] (perception related to preference)	Engineers know
Work better (perception related to preference)	Protect more
Experience (perception related to preference)	Learned about, works in other areas, seen it work elsewhere
Build up coastline (perception related to preference)	Stop erosion, reduce erosion, enhance beach extension
Raise awareness (perception related to preference)	Create engagement, public education

After the data from all the Individual Analysis Sheets were entered onto the Data Compilation Sheet for each study area, the researcher went back to the Individual Data Sheets to make sure that all the codes were captured in the Compilation.

The Data Compilation Sheets for each study area were used to create tables to organize and summarize the findings by the research categories and sub-categories. Those themes that were heard more than once were quantified to assist in analysis. Representative statements given by participants were also included. The eleven categories and sub-categories representing the findings for each study area are:

1) Participants' awareness of mitigation infrastructure that exists in the study area;
2) Source of awareness of existing mitigation infrastructure both offered (without probing) and when shown pictures of local engineered structures and natural features;
3) Awareness of local proposals or planned projects to build or enhance engineered structures or natural features for purposes of reducing hazards. (Included statements on what is known about projects and how residents came to know about projects.);

4) Perception of lower costs associated with creating, enhancing, and maintaining mitigation infrastructures and perception of longer-term benefits. (Included reasons/ explanation of why response was given.);

5) Perception of benefits and problems associated with specific engineered structures and natural features not associated with hazards;

6) Perception on which type of mitigation infrastructure functions better to reduce hazards or impact from hazards. (Included perception of how and clarification of why answer was given.);

7) Perception of the function on engineered structures existing in area and shown with a picture. (Included both the offered responses before and after probing about their function associated with specific hazards.);

8) Perception of the function on natural features existing in area and shown with a picture. (Includes both the offered responses before and after probing about function associated with specific hazards.);

9) Perception of mitigation infrastructures that influence residents' preference and perception of proposed projects, if known about;

10) Perception of the relationship between functions of natural and engineered infrastructures. (Included general perception and specifics on perception of relationships associated with specific hazards, perception of the advantages of infrastructures on one another, and perception if both could be used.); and

11) Residents' range of preferences for mitigation infrastructure. (Includes general preference, if both natural and engineered infrastructure should be used, and preference for enhancing existing or creating new structures or features.)

These tables were essential in summarizing the findings presented in the Results chapter.

CHAPTER 5

RESULTS

The interview findings from the two case studies fall into categories related to the research themes of awareness, perceptions, and preferences and the associated subcategories resulting from the structure and content of the interview questions. Codes and themes emerged from the data for each category and sub-category. The interview findings are presented by study area and organized by research theme. There were also themes that emerged from the data that were common between the two study areas that did not fit into the research categories that are presented in the final section of this Results chapter. The discussion chapter will integrate the findings of the two case studies of the perceptions of coastal residents toward the functions of, relationship between, and preference for engineered and natural mitigation infrastructure.

The most important subcategory of the awareness theme is residents' consciousness of existing natural features and built structures that make up the natural and engineered coastal hazard mitigation infrastructure in the two study areas. Another subcategory is awareness of proposals for new mitigation infrastructure or enhancement of what exists. The subcategories of residents' perception of natural and engineered infrastructure are their perception of: 1) the functions of the individual natural features and engineered structures as they relate to the coastal hazards of storms, coastal flooding and erosion; 2) the benefits and costs they associated with the built structures and natural features; 3) the functions of the features and structures comprising a group of mitigation infrastructure (natural and engineered infrastructure, respectively); and 4) the relationship between the mitigation infrastructures associated with coastal hazards. Lastly, the research category of preference for mitigation infrastructure is composed of subcategories of general preference for the two types of mitigation infrastructures and preference for specific structures or features.

Volunteered Responses Before Being Questioned About Specific Hazards

The responses that were volunteered by study participants before being probed for specifics is highlighted in the findings: these responses indicate what is important to the residents, what they are most conscious of and perceive, and how they frame the topic from their own perspective rather than from the perspective of the research agenda of this study. Residents, when asked if they knew about any built structures or natural features that exist in the area to reduce coastal hazards or impact from coastal hazards, described the existing mitigation infrastructure that is most salient to them: those that come to their mind when thinking about coastal hazards of storms, flooding, and erosion. Some participants expounded on how they think the mitigation structures or features that they offered reduce hazards or impact from hazards. Fifty-four percent (54%) of Laurence Harbor participants volunteered a description of how they think the engineered structures they were aware of are related to the topic of mitigating coastal hazards, and 42% volunteered a description of the natural features they were aware of. Forty percent (40%) and 17% of Union Beach participants volunteered descriptions of those engineered and natural features they mentioned. Participants also volunteered what they thought about specific natural features and structures when shown pictures before the researcher probed with questions specific to types of coastal hazards. These volunteered responses were often further explained during probing from the researcher about the functions of the infrastructures in regards to specific hazards. In the case of Union Beach, close to half of the residents that volunteered that the wetland increases flooding clarified, when probed specifically about flooding, responded that the natural feature does reduce the impact from flooding and clarified their answered with statements such as “water needs to stay in area: if water stayed in area, streets would not flood” (6jh92515).

It is also important to learn how residents came to understand or know about the mitigation infrastructure and what they know and think about proposals for new or enhanced mitigation infrastructure. Residents described how they have come to understand and think about the mitigation infrastructures shown in pictures by describing what they have witnessed. Knowledge of the history of the decisions regarding the mitigation infrastructures was also produced as evidence of experience and influences the perception of mitigation infrastructures. Fifty-seven percent (57%) and 54% of Laurence Harbor and Union Beach participants, respectively, volunteered information about engineered structures based on their experience and/ or knowledge of past decisions. For example, Laurence Harbor residents described how they have seen evidence of the groin’s functions in retaining or moving sand and other effects:

> “Can see how much sand is trapped when the plants die back” (a 67 year-old retired male resident, 11gm11615).
>
> “One part of beach there isn't much beach […] at high tide, all the beach is gone” (a 55-year-old female warehouse worker, 6dh102415).
>
> “One area of the beach is getting bigger while other is getting shorter” (a 64 year-old retired male resident, 7rk102415).
>
> “Seen landscape change due to jetties: beach has grown between jetties #3 and 4.” (a 48-year-old female manager,13jw11715)
>
> “Other area of it used to have a beach before Sandy, and the other side doesn’t have a beach” (24-year-old female secretary, 12cm102415).

Several participants recalled when the engineered structures were constructed: Three (3) residents that have lived in Union Beach each for sixty years recalled when the bulkhead was constructed and offered their perception of the structure: An 86-year-old retired borough tax collector and bank clerk described: "[bulkhead] was done after a storm a long time ago: who would have known it wouldn't be sufficient: we are on the bay not the ocean" (7es92515). An 85-year-old retired telecommunications worker resident recalled the bulkhead being rebuilt and claimed that it "doesn't help much" (9pf92515). And an 83-year old library assistant explained that the area where the bulkhead/ revetment is "used to be a beach and erosion took a long time" (10gb101615).

A 45-year-old manager and life-long Union Beach resident explained that she has "see[n] areas that are affected based on how projects are designed […] certain areas like Schoeler Park were wetlands, but they created concrete around it […] Ever since Schoeler Park was created and houses built [in area], even with basins, [area] has more flooding: changed the flow of water" (13jv112115). A 67-year-old retired administrator of a legal department and resident of Laurence Harbor for twelve years spoke about his knowledge of the area and prior decisions: "[This] area used to be marshy land […] [part of the] coastal recovery plan (a joint effort of USACE and State) was to include storm abatement structures: the first thing they built was the jetties, filled in area where seawall is" (11gm11615).

Fifty-seven percent (57%) and 77% of Laurence Harbor and Union Beach participants, respectively, volunteered information about natural infrastructure based on their experience and/or knowledge of past decisions. When discussing the natural features shown in the pictures, residents adduced their experience:

> "Can see [that] on the beach side [of wetland], during storm no damage […] and houses nearby don't have erosion" (a 42-year-old female executive from Laurence Harbor, 9sm102415).
>
> "With oyster beds we had out here [in past] didn't have nasty floods" (a 61-year-old chef and life-long resident of Laurence Harbor, 4kh292715).

Some described the wetland by providing evidence of what they have witnessed:

> "Doesn't have an outlet, it overflows during regular tides and precipitation" (a 37-year-old nurse from Union Beach, 1ak91815).
>
> "[It is a] barrier, in most instances, Sandy was different, flooded there" (49-year-old accounting supervisor who has lived in Union Beach for 20 years, 5jc91915).

Experience from living in a coastal community with the existence of the mitigation infrastructures and with coastal hazards influences the awareness and perception of the infrastructures. Experience is not always the same among residents and perspectives are different. For example, when discussing the wetland area in Laurence Harbor two (2) life-long residents had opposite recollections of the area over time: A 21-year old female who has a college degree in biology said that the wetland hasn't changed much (12cm11715) while a 61-year old man with a high school diploma said that the wetland had changed over time: "[wetland] used to be creeks, now its man-made and can't flow because of the silt" (4kh292715). A 72-year-old retired Laurence Harbor resident's response shows that witness and observation is important to perception: "I've seen the jetties working, haven't observed the natural [features] working" (14df112015). She also said that she was "not familiar with [the wetland] […] never really paid attention to it". This resident was unable to answer when asked about the functions of the wetland. She was able to describe how she thinks the groin works because she has "seen it modify the direction of water". Her perception was that this modification of the flow of water helps reduce coastal erosion and may reduce impact from storms.

A 24-year-old life-long resident of Union Beach explained what she witnessed during Superstorm Sandy: “During Sandy water came from the Bay through the marsh and into [the] Morningside area, that’s how people and the park go flooded over there” (12cm102415). This resident’s perception of the wetland was that it is an artery for water and contended that the only reason the wetland area exists is because there are prohibitions against building on it. She believes that the wetland does not reduce impact from storms and actually increases flooding and asserted that there are no options for the wetland other than filling it.

Awareness can also come from what is heard or learned about the engineered structures and natural features. The most common sources of awareness for the two study groups are social sources (family, friends, neighbors), formal institutions (community organizations, government officials and meetings therewith) and personal investigation/ inquiry (studying, asking questions, tracking down information). The sources of residents’ information are important for policy making and engagement of the public. The research findings also present where residents are getting information.

The awareness or consciousness of existing infrastructure is important to this research as it indicates what is salient to the residents in coastal areas: in this case, what they think about when asked about mitigation infrastructure. A number of study participants noted that they had not thought about some of the structures and features before being asked about them specifically. For example, a couple of study participants said that participating in the study (having a discussion about the topics of hazard mitigation and infrastructure) gave them things to think about: “[You’ve] given me a lot of things to think about that I don't usually spend time thinking about" said a 48-year-old woman from

Laurence Harbor, 13jw11715). This research finds that even if a structure or feature is not salient to someone, they may still have an opinion on how it might function. A 55-year-old manager from Laurence Harbor with an advanced degree in systems engineering stated that she didn't think about the dune area shown in the picture when first asked about existing natural features. She was able to describe her experience with the natural feature and used that experience to make some conclusions about its function: "[dune area is] not totally gone after a storm […] have to say yes [that the natural feature reduces erosion] because that part of the beach hasn't changed much over the years […] [its] been the same size as I can remember" (6dh102415).

5.1 Laurence Harbor

5.1.1 Awareness of Mitigation Infrastructure

The majority (93%) of the study participants from Laurence Harbor (LH) were aware of the existing engineered infrastructure in their town. Those structures that were mentioned the most were the groins (ten (10) times), revetment (eleven (11)), and cliff rocks (six (6)). Only one (1) participant mentioned dunes as a built structure. No one responded that "there aren't any" structures to mitigate hazards. Fifty percent (50%) of the LH participants volunteered some explanation of what they thought of the role of the engineered structures:

> "Cliff rocks stop storm surge" (73-year-old retired man, 2kh92715).
>
> "Boulders were brought in after Sandy because of erosion" (24-year old secretary, 12cm11715).
>
> "Jetties direct flow of water, seawall reduces erosion" (72-year-old retired woman, 14df112015).

Two residents, a 67-year-old retired administrator and 24-year-old secretary, both claimed that the revetment was "built to stop erosion" (11gm11615, 12cm11715).

A majority (86%) of LH residents in the study also volunteered particular types of natural features that they believed serve to mitigate coastal hazards. Only two (2) participants said they did not know of any natural features that serve a mitigation function. Most salient to the residents was vegetation (seagrasses or trees). Five (5) participants mentioned wetlands, and two (2) also mentioned tidal creeks and the inlet. Four (4) LH residents mentioned shellfish beds as natural features that serve to mitigate coastal hazards. Residents also mentioned dunes and the cliff when asked about natural features in the area that serve to reduce coastal hazards or impact from coastal hazards: three (3) participants mentioned dunes and two (2) people named the cliff as a natural feature that mitigates coastal hazards. Thirty-six percent (36%) of LH participants volunteered explanation of how they think about the natural features they were familiar with:

> "Across the highway they have swamps back there […] when the surge come in, guess they flood" (55-year-old warehouse worker with a high school diploma, 6dh102415).
>
> "Before Sandy where rock wall [at cliff] is now used to be covered with trees and plants, a good way to keep land together to prevent erosion" (24-year-old secretary who studied biology in college, 12cm11715).
>
> "Every natural feature along the shore help to do that; [they are] a reserve/ buffer/ sponge between us and being destroyed […] I know my house was not destroyed because [the] wetland was there" (44-year-old city planner with degrees in environmental science, political science and planning, 8kh3102415).
>
> "Wetland [is a] runoff area and buffer to tidal flooding" (67-year-old man with a background in law and economics, 11gm11615).

Two (2) Laurence Harbor (LH) residents mentioned difficulty deciphering what is truly natural and not touched by human manipulation. A 24-year-old, life-long resident, when asked if she knew about any natural, environmental features that serve to reduce coastal hazards, first responded that she didn't know if there are many natural features left and explained that the "dune [by police station] is not natural: most everything is man-made now" (12cm11715). After thinking about the question, she offered that the trees and plants that used to cover the cliff were "a good way to keep the land together [and] figure the roots in the ground prevents erosion […] didn't notice much erosion". A 30-year-old stay-at-home mom who has been living in Laurence Harbor for seven years stated "I think everything is man-made now, I can't tell the difference" (3tb92715) and was unable to offer any existing natural features she was aware of that serve to mitigate coastal hazards. She offered explanation of the functions of the dune area when shown a picture, but did not offer explanation of the function of the wetland.

5.1.1.1 Sources of awareness. The main source of awareness of existing mitigation infrastructures for LH residents was from seeing or experiencing, a few residents also said they have studied (proactively learned about through inquiry) the natural features and built structures. Four (4) participants said they became aware of the engineered structures from the government. Other sources of awareness were the news/ media, family/ friends, and organizations. Nearly all awareness of the structures and features shown in pictures came from the participants recognizing them and admitting that they know about them from seeing them. The source of awareness of proposals or planned projects for engineered structures included from news/ media, friends/ family, government and organizations while awareness of natural projects was more likely to come from organizations or the government.

5.1.1.2 Awareness of planned projects or proposals. Most of the LH participants were unaware of proposals for new or enhanced engineered or natural infrastructure. The most commonly known proposals and planned projects were the revetment and addressing the lead contamination (five (5) residents mentioned). Residents mentioned the limitations of the engineered structures because of the contamination.

When asked about planned projects or proposals for natural infrastructure, a resident of 12 years, who had moved to Laurence Harbor to be near the water, mentioned discussions on addressing flooding near Paul's Beach by working in the wetlands: "[They are] looking for way to block flooding in area of Paul's Beach, [proposing a] berm by wetland [made up of] dredge material" (11gm11615). Both wetland preservation or restoration and property buyouts were both mentioned three (3) times.

5.1.2 Perceptions of Mitigation Infrastructure

5.1.2.1 Functions of mitigation infrastructure. Several participants from LH volunteered what they think about the built structures and natural features in their area when shown pictures before being probed about their functions associated with specific coastal hazard: 79% of participants volunteered their perception of the functions of the revetment, groin, and wetland and 86% volunteered information about the dune area. Eight (8) of fourteen (14) participants offered that the revetment served to reduce erosion: explaining how they think about the structure's function. A 55-year-old woman who has lived most of her life in Laurence Harbor believed that the built structure retains sand and helps reduce erosion that results from regular storms:

> "[Revetment] does help [during normal storms], otherwise there wouldn't be any sand" (6dh102415).

Other residents, in initial response to the picture, shared that the revetment reduces flooding, breaks waves, and buffers wind. A 67-year old retiree who grew up in Laurence Harbor and stays for the fishing and the water explained that although the structure may reduce water locally, it could displace water:

> "[Revetment] stop[s] water but may cause tide to come over to other areas" (7rk102415).

When asked about specific hazards, the majority of the LH participants responded that the revetment reduces the hazard or impact from storms and erosion, three (3) were not sure of its function during storms and two (2) people clarified that its function in mitigating erosion is localized. Common themes were that the revetment functions to break waves/ water, serves as a buffer, reduces erosion during storms, and keeps sand. A little under half of the LH residents interviewed think that the revetment reduces flooding coming from high tides while about the same number of participants did not think the revetment reduces (or makes a difference in mitigating) flooding. Some of the residents who responded that the structure reduces flooding clarified that the structure also deters water from going back out and only protects the landward side of the revetment contributing to erosion on the bayside.

When shown a picture of the groin, several LH participants volunteered how they think the groin functions. Before being probed about specific hazards the common explanations given were that the groin functions in collecting or moving sand. A 50-year old firefighter specified that the groin helps "stabilize the beachfront" (10bm11615). Two (2) people said that the groin interferes with long shore current. A 67-year-old man who has lived his whole life in LH said that the groin "doesn't let the tide flow the way it used to" (7rk102415). A few participants further explained how they think the groin functions and impacts sand movement: A 42-year-old woman who has lived in LH for fourteen years said that the "[groin] captures sand on one side, area west of first jetty [has] lost [its] beach" (9sm102415). The 67-year old life-long resident that believed that the groin interferes with the tidal flow said that "[in the area of the groin] sand gets taken from one beach and gets deposited to other areas" (7rk102415). A 67-year-old retired legal administrator explained his perception of the engineered purpose of the groin: "The intent [of the groin] is to prevent sand from being washed away" (11gm11615).

Two (2) residents when first viewing the photograph of the groin offered that they did not understand how the groin could help reduce impact from coastal hazards because of its perpendicular orientation with the shore:

> "[Groin is] supposed to help [but] it doesn't make sense to me that something sticking into the water helps with erosion" (55-year-old warehouse laborer, 6dh102415).
>
> "Not protecting the land because it's perpendicular, not parallel, and just covers one spot" (24-year-old secretary, 12cm11715).

Three (3) participants, also before being probed about specific coastal hazards, volunteered that the groin breaks up waves.

When the researcher asked about the functions of the structures associated with storms, flooding and erosion, residents further expanded on their responses to the photos of the existing engineered structures. The LH residents' perception of the groin's function in mitigating the impacts from storms was mixed. Three (3) residents were not sure about the groin's functions during storms, three (3) said that its ability to reduce impact from storms depends on the storm or direction of the waves, two (2) people said the groin does not reduce impact from (or make a difference during) storms. Residents were more in agreement that the groin does have a role in mitigating flooding: twelve (12) of the fourteen

(14) LH residents interviewed did not believe that the groins make a difference or reduce flooding. Two (2) residents, when describing their perception of the groin and its functions associated with flooding, mentioned that the structure break waves which may reduce flooding. A 72-year-old resident of thirty-seven years, who described herself as living in "the wet part of town", clarified that she assumed that is why the groins are there: to reduce flooding (14df112015). The residents of LH mostly associated the groin with reducing erosion (nine (9) of the fourteen (14) residents answered this way), a similar response to what they first volunteered when shown the picture. When probed about the groin and its functions related to erosion, explanations included that the groin redirects water, prevents large scale erosion, and reduces erosion only on one side of the structure.

When shown a picture of the Marquis Creek wetland and before being asked about the natural feature and specific coastal hazards, many LH residents offered descriptions of the natural feature as a place for water to go or its role in reducing flooding. Two (2) participants volunteered that the wetland can reduce impacts from storms. Three (3) participants reported how the wetland gets blocked from draining adducing:

> "[Wetland] cannot flow because of silt" (61-year-old chef, 4kh292715).
>
> "If [there is] enough vegetation, water stays there until high enough to break plug [and flow out]" (55-year-old female warehouse worker, 6dh102415).
>
> "Flow in area gets cut off" (67-year-old man, 11gm11615).

However, before being probed about the feature's role during storms or related to flooding, no one directly stated that the wetland causes flooding. Two (2) residents purported that the wetland absorbs or dissipates energy of the tide or velocity of the water.

Two (2) residents expressed comfort in the presence of the wetlands in mitigating impact from storms or coastal flooding:

> "[I] know my house was not destroyed [during Sandy] because wetlands were there" (44-year-old man, who moved to the area for convenience to work, being near the water, and the affordability of the area, 8kh3102415).

> "[I] actually feel safer from rain events on shore than when lived inland […] [there are] so many places around for water to go" (42-year old woman who has been living in Laurence Harbor for 14 years, 9sm102415).

When questioned about specific hazards, the majority (64%) of participants discerned that the wetland reduces flooding, erosion, and impact from storms. The most common illustrations of the wetland's functions were breaking waves, being a buffer, keeping sand, and being a place for water to go.

> "The more square-footage [of the wetland area] the lower the height of the tide" (a 48-year-old real estate manager, 13jw11715)

Several residents were not sure of or said they did not know about the wetland's functions: four (4) were unsure of the wetland's functions associated with storms, four (4) were unsure of its functioning associated with erosion and four (4) were unsure if the wetland reduces flooding. And only one (1) resident believed that the wetland doesn't make a difference in mitigating flooding from high tide or storms:

> "During high tide, [wetland] doesn't cause […] doesn't reduce [flooding] […] [and] during surges everything floods" (55-year old woman, 6dh102415).

Although not volunteered when first shown the picture of the wetland, two (2) LH residents, when probed about the natural feature and flooding, said that the wetland can cause more flooding. "[Wetland] can be hazard when storm events are dissipated into area" (67-year-old man, 11gm11615). Three (3) people clarified that the functions of the wetland in regards to flooding was dependent on the storm event. "[Wetland] will not cause flooding unless really huge storm" (32-year-old software engineer, 5pv101615).

Some of the common portrayals of the dune area at Forbes Beach, when shown the picture before prompting about specific hazards, were that this natural feature reduces impact from storms, mitigates wave action, reduces erosion and builds up sand, reduces flooding, soaks up water and/ or serves as an outlet for water. A 42-year-old wholesale company executive pronounced the dune area a “coastal flooding mitigation area” (9sm102415).

When prompted, overwhelmingly, LH residents said the dune area reduces impact from storms, mitigates flooding, and reduces erosion. One (1) resident believed that the area reduces erosion, not just locally, also further back, away from the coastline. Two (2) people said that the dune area does not reduce erosion. Two (2) people were not sure how the dune functions in mitigating the impacts from storms and one (1) person said it doesn’t make a difference to flooding. Common explanations were that the dune area keeps sand, breaks water, serves as a buffer: “[Dune area] reduce[s] damage to Route 35 by dissipating energy” (42-year old woman, 9sm102415), is a place for water to go mitigating damage to nearby property: “During high tides [dune area] holds up excess water preventing [water] from entering homes and roads” (32-year-old woman, 5pv101615). A 48-year-old manager contended that “[there is a] reason why there are no houses on it […] (dune area) reduces flooding of nearby homes” (13jw11715) and a 32-year old software engineer who has live in Laurence Harbor for eight years echoed the sentiment by saying, "If people started living there, where would water go?" (5pv101615).

5.1.2.2 Benefits and costs. When asked directly, eight (8) of the fourteen (14) Laurence Harbor residents said that engineered infrastructure is better at reducing hazards or impact from hazards. Two (2) people believed that natural features are better. One (1) person said both (together) are best for the different benefits they provide and one (1) person said neither infrastructure is better at reducing coastal hazards or impact from coastal hazards. Two (2) said it depends on where the infrastructures are located. Most of the reasons, if given, were how the structures work better to reduce hazards: the engineered structures reduce erosion, break waves/ surge, hold back water, or simply "protect people". Explanation for why engineered infrastructure works better were that engineered structures are more predictable and that there is knowledge of how to fix them. Participants also said that built structures protect natural features or are needed because of damage to the natural features.

A 62-year old retired telecommunications researcher and developer with a PhD in mathematics who has lived in Laurence Harbor for close to six years gave the following explanation of the benefits of engineered infrastructure: “[We] would have lost a lot more at park [during nor'easters] if the seawall hadn't been there” (1dw92515). Two (2) people mentioned that engineered infrastructure allows for development:

> Human development wouldn’t have occurred if built structures weren't there” (a 67-year-old retired administrator, 11gm11615).
>
> “[Engineered] structures allow us to build” (24-year old and life-long resident, 12cm11715).

A 32-year-old software engineer, who has lived in LH for eight years and stated that her reason for living in the areas is for her job, house, and being near the water, explained how the infrastructures co-exist: “Natural areas help reduce water/ flooding, [revetment] helps land from eroding” (5pv101615).

Several of residents also explained the problems they see with engineered infrastructure:

> "Rock jetties cause coastal problems: not built right […] jetty [is] causing the channel by bridge to fill in with sand creating a navigational hazard […] jetties cause problem where they lost a lot of the beach during the storm [eroded as a result of the jetty]" (64-year-old life-long resident, 7rk102415).
>
> "Poorly constructed built structures create problems more than natural features" (67-year-old retired man, with a Master's degree in law, 11gm11615).
>
> When asked about potential problems a 61-year-old, life-long resident simply stated: "[The] beach was better when left alone" (4kh92715).
>
> A 44-year-old city planner said that "while [built structures] serve for the short term [and] seem to reduce some impacts, [they] exacerbate impacts in long term […] built [structures] can increase coastal flooding […] [I] think about the long term consequences." (8kh3102415).
>
> A 30-year-old woman who has lived in Laurence Harbor for 7 years said: "[I] don't think we could build something big enough for a Sandy storm" (3tb92715).

Although the majority of residents perceived engineered infrastructure to work better to reduce hazards than natural infrastructure, some described how the natural infrastructure is beneficial:

> "[Wetlands are] helpful [….] the way it should be" (73-year-old man, 2kh92715).

Two female residents perceived a benefit of natural infrastructure to be its ability to regenerate:

> "Natural [features] grow back, rocks have to be replaced" (24-year-old secretary, 12cm11715); "Natural [features] come back on its own" (55-year-old warehouse laborer, 6dh102415).

The majority of the Laurence Harbor study participants (over 70% percent) perceived natural infrastructure to have a lower cost (or no cost) and requiring less maintenance. Two (2) participants said they did not know which type of infrastructure costs less and one (1) said that built structures are less costly. Common explanations for the perceived lower cost of natural infrastructure was the use of fewer materials, less maintenance, and less labor, as well as the fact that built structures have to be fixed. Three (3) residents mentioned that natural infrastructure has a lower cost because the features already exist.

Some participants gave caveats in comparing costs between natural and engineered infrastructure. A 61-year-old who grew up in LH said that: "to get natural [infrastructure] to have lower cost, need to move built structures" (4kh292715). Another male resident in his sixties who has lived in LH for twelve years mentioned: "what you don't spend on natural features could spend on built [structures]" (11gm11615). He also mentioned that over time the revetment is only a portion of the benefit compared to the dune: "Revetment is $0.10 solution where dune is $1.25". A 73-year-old retired motor manufacturer (2kh92715) considered the cost of the built structures and human health given the fact that much of the engineered mitigation infrastructure in Laurence Harbor is part of a Superfund site.

Most of the LH residents also perceived natural features to have a longer-term benefit over built structures. The most common explanations were that they the natural infrastructure is self-maintaining and provides ecosystem benefits. Other benefits cited include that the natural features last longer and improve with time. A few residents gave reasons why built structures lack longer-term benefits:

> "[Built structures] are a short term fix" (24-year-old with a college degree in biology, 12cm11715).
>
> "Not sure there is a benefit over time with built structures: get washed away" (55-year-old woman who loves being in LH because of family and the community, 6dh102415).

Only two (2) residents claimed that built structures have a longer term benefit either because they longer or protect more. Some of the perceived long-term benefits were unique. One (1) resident tendered that a benefit of both infrastructures is raising awareness as well as being a teaching tool. Another resident contributed that natural features are a benefit because they do not create disasters.

Most of the participants recognized ancillary benefits of both types of infrastructures. These benefits for engineered infrastructure include recreation (fishing and views) and habitat for wildlife (revetment). Other perceived benefits included increasing property values, attracting visitors, and improved safety. The most commonly mentioned benefit of natural infrastructure was habitat for wildlife. Recreation, beauty, and environmental services, such as water quality improvement, were also offered as benefits to natural infrastructure.

The most common perceived problem of the existing engineered infrastructure was the lead contamination and the resulting blocked access or limited recreation as well as garbage left or collecting around the groin. Two residents, a 44-year-old city planner and 32-year-old software engineer, had the same sentiment about the groin:

> "People should not be fishing there due to contamination" (8kh3102415, 5pv101615).

One benefit of the engineered infrastructure mentioned by a couple of residents was the impression it gives: that its existence make people feel good or serves as evidence that the area is being taken care of. The most common problems residents perceived of natural infrastructure were bugs (flies, mosquitos, and ticks), odors, dumping or collection of trash. Some unique perceptions of the natural features included being unsafe or a fire hazard, attracting unwanted visitors, blocking views, having the potential for being invasive, and producing odors or rodents.

5.1.2.3 Relationship between infrastructures. The effect of mitigation infrastructures on each other is important to consider when utilizing both infrastructures to reduce coastal hazards or impact from hazards. All of the study participants from Laurence Harbor said that both natural and engineered infrastructure could be used to mitigate coastal hazards. Most of the LH residents participating in the study (nine (9) of fourteen (14)) also believe that natural and engineered infrastructure affect each other if located near each other. About half of those that believe the infrastructures affect each other described the relationship is a positive one: that the infrastructures reinforce or support each other's function, that they can work collectively. Explanations of the infrastructures supporting the function of each other included that together they form a more effective barrier or lessen the impact of coastal hazards on the other:

> "Built [infrastructure] support [the area] where natural [infrastructure] has been disrupted" (73-year-old retiree, 2kh92715).
>
> "[We] wouldn't have a beach if didn't have each other [both natural and engineered infrastructure]" (55-year-old female, 6dh102415).

The other half of those residents that responded that natural and engineered infrastructure affect each other perceive the relationship to be a negative one: that the infrastructures conflict or contradict each other's functioning. Two (2) residents explained that problems associated with coastal hazards are just moved between infrastructures, claiming both infrastructures co-existing "move problems". Explanations given of the negative relationship included that engineered infrastructure can increase erosion of natural features such as the jetties altering the flow of water and thereby determining if sand will erode or the built structures reducing the ability of natural features to function. Others mentioned a conflict between natural features and engineered structures whether natural affecting the existence of engineered structures or engineered structures negatively influencing the natural features' functioning:

> "More natural [features] would jeopardize the wall […] More built [structures] would take away from natural [features] [and there is] more impact on natural [from the built structures] then intended […] end up with likelihood of flooding in tidal basin [from] obstruct[ion] [of the] natural flow" (67 year-old retired legal department administrator, 11gm11615)

> "Too many man-made structures or designed in the wrong way can reduce ability of natural features to provide all their benefits" (44-year old city planner, 8kh3102415).

> "Can't build more marshes where they were before, if built [a] wall by [the] creek, [the] creek would dry up" (64-year-old man who grew up in LH, 7rk102415).

> "[Built structures] might not allow natural features to do what they are supposed to do themselves" (24-year-old woman who grew up in LH, 12cm11715).

Four (4) residents were unsure if the infrastructures affect each other and one (1) person said that they do not believe they affect each other: that they work the same without each other. When further probed, three (3) residents said that the infrastructures do not affect each other's functioning. Explanations included that they perform different functions. A couple of residents elucidated that it depends on how the engineered structures are made:

> "If material is not right could affect the ecosystem" (50-year-old firefighter, 10bm11615).

A 44-year old city planner stated that he "could see that if there is too [many] man-made structures or [they are] designed in the wrong way [could] reduce ability of natural features to provide all those benefits" (8kh3102415). He also explained that the effects of the infrastructures on each other are scale dependent, that the relationship between the infrastructures at the scale of the pictures shown are small and warned that what is important is to considered the relationship between and effects on each other at a larger system scale: “[It is] not just about the features and structures shown at this scale, need to zoom out, impacts at the small scale are minimal”.

When asked further about the relationship to be thought of as an advantage to one type of infrastructure as a result of the other, residents were also divided. Five (5) residents perceived a benefit to the engineered structures from the natural features most of them saying that natural decrease the impacts of coastal hazards on the built structures. Conversely, six (6) residents said there was no advantage to the built from the natural features and two (2) residents perceiving the natural features to be actually be a disadvantage to the built structures. On the advantage of built structures to the natural features, residents were mixed: four (4) saying there was an advantage while four (4) said there was not an advantage to the natural features by the presence of the built structures, only one (1) resident specified that there was a detriment to the natural features from the presence of the built structures. One (1) person said that the built structures may increase erosion by the natural features. Three (3) residents said that it depends on the location of the infrastructures. Some explanation of an advantage was that the built structures encourage the spread of vegetation and help protect natural features.

Although divided on the effects or benefits of infrastructures on each other, when residents expanded on the perceived relationship between the infrastructures when probed about influence of the two types of infrastructures on each other in regards to specific coastal hazards, approximately half of the participants identified a positive relationship between the infrastructures (either enhancing or reinforcing the function of the other) associated with storms, flooding, and erosion. The other half of participants were divided between perceiving a negative relationship (conflict) or no relationship between the infrastructures associated with these specific coastal hazards. Only three (3) LH residents perceived a conflict between the infrastructures. Three (3) residents said they were unsure of the relationship between infrastructures associated with flooding and one (1) person claiming that the relationship depends on the location of the infrastructures, two (2) unsure about the relationship during storms, one (1) person clarified that it depends on the location of the infrastructures, and only one (1) person was unsure of a relationship between the infrastructures associated with erosion.

Explanations of the relationship between the infrastructures associated with storms included that they work together to prevent erosion, that the built structures protect the natural features or divert water to them. LH residents shared a range of explanation of the relationship between the infrastructures associated with coastal flooding: built structures can increase the pressure on natural features, the wetland can protect areas from flooding that the groin cannot, natural features decrease the impact on built structures, and there is no effect of the two types of infrastructure on each other when there is a lot of water. Description of the relationship of the infrastructures associated with coastal erosion included that the built structures buffer the natural features, that the groin prevents the inlet from silting up, and that the natural features reduce water movement (thereby reducing erosion near the built structures). Those that said there is no effect of the infrastructures on each other explained that they are not near enough to each other.

Those residents that perceived a negative relationship between the infrastructures had justifications such as: "Flooding from the wetland causes erosion on the landward side of the revetment" (62-year-old retired telecommunications researcher, 1dw92515). Those residents that were unsure of the effects of the infrastructures on each other explained their thinking: A 67-year-old resident said he was “not sure if [the] seawall is causing land to wash away into wetlands” and then proclaimed that built structures are "not a direct causation of erosion of natural areas" (11gm11615). Another resident said she was “not sure if the erosion or degradation of oyster beds (in neighboring Cliffwood Beach) is due to proximity of built structures” (42-year old executive, 9sm102415).

Those that perceived a positive relationship between the infrastructures explained that the built structures support, supplement, or protect the natural features, and likewise, the natural features help take the burden off of the built structures:

> “Built [structures] support where natural has been disrupted” (73-year-old man, 2kh92715).
>
> “If natural features capture sand there would be less by built structures” (42-year-old operations manager of a wholesale company, 9sm102415).
>
> “The more square-footage [of natural features] there is to accept the water and can be absorbed [….] will reduce impact to other areas” (48-year-old manager, 13jw11715)
>
> “If [we] didn’t have built structures, natural would go away” (50-year–old firefighter who has lived in LH for 15 years and the vicinity for an additional 30 years, 10bm11615)
>
> “Revetment helps block some of the water from eating away at the beach” (55-year-old, life-long resident, 6dh102415).

All residents affirmatively said that both infrastructures could be used to reduce hazards or impact from hazards with a common response being that both already exist in the area. A 24-year-old secretary and life-long resident thought about using both infrastructures as having both vegetation and built structures: she proclaimed, "there is no conflict between more plants and built structures" (12cm11715). She also believed that if the infrastructures could be combined they might be more effective:

> "Dunes with seagrass would be more protective on top of rock wall, plants would keep the sand there […] Maybe if they added some rocks to the swamp [there] might be a benefit to prevent waves from flooding land."

Two (2) residents clarified that both infrastructures could both be used if "done correctly" reinforcing the perception that a negative relationship might exist. A few participants further explained how they think about the two type of mitigation infrastructures when discussing the relationship between them:

> A 50-year-old firefighter who said the "[revetment] becomes a part of the ecosystem" also proclaimed that "sometimes it's not good to mess with Mother Nature, could shift problem elsewhere, some places are meant to be lived in" (10bm11615).

> A 42-year old resident who chose LH to be near the water and its convenient location explained that mitigation from engineered structures is just local and problems could be directed elsewhere: "[The groin] may save a house in one area [while] another area could be flooded" (9sm102415).

5.1.2.4 Perceptions associated with preferences. Perception of the infrastructures influence preference for what should be used to mitigate hazards. There was a range of explanations LH residents gave for their preferred types of mitigation infrastructure whether the preference was for more engineered or natural infrastructure, having both, or the detriment to having more natural features:

> Two residents claimed that they perceived the built structures to be performing well to mitigate coastal hazards: "Built seem to be doing a good job" (72-year-old woman who has lived in LH for 37 years, 14df112015) and "What we have does a good job" (50-year-old retired administrator, 10bm11615).

> A 42-year old woman who studied geography in college expressed that the area "might be too far gone [from erosion] to get benefit from natural features alone" (9sm102415).

> "Marsh better than rocks just lying there" (32-year old software engineer, 5pv101615).

> A 61-year old chef whose lived in LH his whole life expressed his interest in natural features by describing that "if the [shellfish] beds were retained [we] wouldn't have [our] current problems [and] wouldn't have to worry about built structures" (4kh92715).
>
> On explaining her preference for more vegetation, a 62-year old retiree who lives close to the cliff described that "trees stabilize slope and break up waves" (1dw92515).
>
> A 67-year-old man retired legal administrator expressed concern with enhancing natural infrastructure: "More natural would just create a tidal basin" (11gm11615).

The most common explanations of preference of specific structures/ features were the perception of them working better to reduce hazards or impact from hazards and ability to build up the coastline, as well as ecosystem benefits. Also heard was the visual improvement from use of mitigation infrastructure, remediation of contamination, provision of long term benefit, as well as the raising of awareness of hazard mitigation and ability to increase public engagement. Only one resident explained that they preferred built structures because they were designed to reduce hazards.

Residents were also specific on how their preferred structures and/or features could enhance their community. In addition to the perception of being better to mitigate hazards, residents perceived improved recreational opportunities, increasing property values, and improving the environment.

Of those LH residents that were aware of proposed projects, there was more skepticism on the engineered works (which was only action to address contamination of the existing structures, not new structures) than enhancing natural features (through provision of open space through property buyouts or work in the wetlands to improve drainage). Opinions given about proposed projects included:

> "Nothing better or worse is going to happen by fixing [revetment]" (30-year old stay-at-home mom, 3tb92715).

> "[I'm] concerned about noise and dust [from working on the revetment] […] [but it'll be] good to remove warning signs and will be nice after it's done" (a 72-year-old woman, 14df112015).

> "Will have to add something to Superfund Site [revetment] […] need something there, maybe a bulkhead like Keyport" (50-year- old man, 10bm11615).

> "Proposals [include] encapsulation and a walkway [by revetment]: although attractive for recreation [it] would eliminate interface between shore and land and create the problem of water getting out once in area" (42-year-old woman, 9sm102415).

> "Wall is essential because tides are higher [but they] could incorporate more drainage […] flooding by Paul's Beach is due to putting structures in area" (67-year-old man, 11gm11615)

There was some positive perception of buyouts from LH residents albeit none of the residents lived in an area targeted for buyouts:

> "Buyout would be fantastic: land [is] not treated as it should […] [would] good for property values, good for wildlife, need to preserve land" (42-year-old woman who has lived in Laurence Harbor for 14 years, 9sm102415).

> "[Buyout would] reduce repetitive losses […] [its] too expensive to stop flooding" (67-year-old man who has live in LH for 12 years, 11gm11615). The same gentleman also contended that more education of the public and officials might advance enhancement of natural features stated that "[There is] not much action on natural enhancements […] need more education."

5.1.3 Preferences for Mitigation Infrastructure

Laurence Harbor residents in the study had mixed preferences for what type of infrastructure they preferred for their community: three (3) specified natural, four (4) preferred engineered and four (4) wanted both, one person saying that it depends. Two (2) residents were not sure or didn't know what they would prefer. A resident who did not live close to the coastline focused on the residents there saying it depends on the problem they are facing: "If had a house near Shoreline Circle and I had a wind problem, I would say I need more grass so sand doesn't get on my lawn, if water is problem, say need a higher seawall" (30-year-old stay-at-home mom, 3tb92715).

A couple of those residents that preferred engineered structures did have conditions for their use:

> "[Revetment] should be there until a more comprehensive solution is come up with" (44-year old city planner, 8kh3102415).
>
> "Okay with higher seawall as long as they take care of where water goes" (67-year-old retired administrator, 11gm11615).
>
> One resident thought that a wall should go up if they know a storm is coming (24-year-old secretary, 12cm11715). Another admitted that natural features might not be enough to address erosion: "[Area] might be too far gone [from erosion] to get benefit from natural features alone" (42-year old executive, 9sm102415).

A few residents clarified their preferences as not wanting more built structures all over:

> A 55-year-old woman who has lived in Laurence Harbor for 51 years proclaimed: "I don't want to see more rocks along beach" (6dh102415). Another resident also did not prefer more rocks but said, "I don't want to see a metal wall, need something instead of rocks" (13jw11715).
>
> "[Should] bring back what was here historically […] don't want to see structures that have to constantly be rebuilt" (44-year old man who has lived in Laurence Harbor for 14 years, 8kh3102415).
>
> "Rather see nothing" (A life-long resident of 61-years, 4kh292715).

There was also a focus on improvements to the natural features:

> "Need to prevent Marquis Creek from becoming permanent lake and bringing more water into the area" (67-year old retired administrator, 11gm11615).

When asked about specific types of structures or features, the majority of the residents mentioned more vegetation (6) and a number wanted a seawall/ floodwall (3), more cliff rocks (4), and shellfish beds (3). Two (2) people mentioned beach replenishment and two (2) enhancements to the wetlands. Only mentioned once each were preference for groins, dunes, or a comprehensive system. Most of these structures and features are existing, except the shellfish beds, so when asked what to improve upon, the answers on what was preferred were about the same. Although none of the participants lived in the area of Laurence Harbor targeted for Blue Acres' buyouts, only one (1) resident said they would like to see the buyout program be enhanced.

> "Don't think need major improvements: use best of natural and built features as they exist- just maintain" (67-year-old man, 11gm11615).

Five (5) participants said that there was no new mitigation infrastructure that they would want. Most of the "new" infrastructure that residents preferred are more of what exists, except one (1) resident that wants a bulkhead

5.1.4 Synthesis

Laurence Harbor residents were quite cognizant of existing infrastructure, most mentioned the groins and revetment before being shown pictures of these structures. LH participants also mentioned the rocks at the base of the cliff that were brought in after Superstorm Sandy to shore up the eroding cliff. Residents also commonly mentioned vegetation as part of the existing natural infrastructure that serve to mitigate hazards.

Most of the themes from the Laurence Harbor study were related to the coastal hazard of erosion. Laurence Harbor residents are conscious of the rocks at the base of the cliff and a several mentioned the trees that used to stabilize the cliff. The comments of a 24-year-old secretary and life-long resident summed up her awareness of existing and former infrastructure as they relate to erosion: "Boulders were brought in after Sandy because of erosion […] Before Sandy where rock wall is now used to be covered with trees and plants [its] a good way to keep land together to prevent erosion" (12cm11715). A 67-year-old retired legal department administrator mentioned that the current vegetation on the cliff is "not good for reducing erosion" (11gm11615). A common explanation of why certain structures or features function better was that there is less erosion. LH residents also explained that the groins are causing erosion and result in the inlet filling in with sand. The most common volunteered explanations of the existing engineered infrastructure were associated with erosion or moving sand. Nearly all residents proclaimed that the revetment reduces erosion when probed. And, the most common offered description of the dune area was that it reduces erosion.

Also, during discussion on the relationship between the infrastructures, one (1) resident specified that one of the advantages of the natural features is that it reduces erosion near the built structures, another said that the built structures may increase erosion by the natural features. A 55-year-old female resident specified that the "revetment helps block some of the water from eating away at the beach" and went on to say that "[we] wouldn't have a beach if [infrastructures] didn't have each other" (6dh102415). A 24-year-old secretary (12cm11715) claimed that plants keep the sand and could protect a rock wall is there was a dune with grasses on top of it. When another resident, a 42-year-old woman explained that "if natural features capture sand there would be less by the built structures" (9sm102415).

The majority of the LH residents in the study believed that the revetment reduces impact from storms and both it and the groin mitigates erosion, and that both the wetland and dune area reduces all coastal hazards discussed. The strongest concurrence was that the revetment reduces impact from storms and mitigates erosion and that the dune reduces flooding, impact from storms, and reduces erosion. Less than half of the residents perceived the revetment to mitigate flooding or the groin to mitigate storm impact. And, nearly all residents concurred that the groin does nothing to mitigate flooding.

The most volunteered explanations of the infrastructures by LH residents before being probed was of the dune area. There was a range of offered descriptions of how the dune area functions: from building up sand and reducing erosion, mitigating wave action, reducing impact from storms, reducing flooding and absorbing water to reducing erosion (most common explanation). There was also the strongest positive response of mitigation functions of the dune area when probed. Still a little over half of the LH residents purported the engineered infrastructure to function better to mitigate coastal hazards.

Residents were divided in their perception of a relationship between infrastructures before being probed about their relationship and specific coastal hazards. Although more than half of the LH study participants perceive that the natural and engineered infrastructure generally affect one another when located near each other, they were divided on if the effect is positive or negative. This was also evident when explaining the advantages of the infrastructures on the other. When considering specific hazards of erosion, flooding and storms about half of the LH residents perceived the relationship between the infrastructures to be a positive one when only four (4) offered this when asked generally about the relationship between the infrastructures. Preferences for what types of mitigation infrastructure should be used was mixed: approximately a third preferring natural, a third preferring engineered and a little less than a third preferring both.

Connection among themes

Seagrasses and vegetation were not only the most salient natural features existing in the area that residents perceived to mitigate coastal hazards, they were also the most common preferred natural feature. There was the most response and range of volunteered descriptions of the dune area. Vegetation, in the form of seagrasses (shown in the picture of the dune area), was specifically mentioned when asked about natural features participants were aware of that exist in the area to mitigate hazards. Other preferred features/ structures were also those features/ structures that residents were aware of: shellfish beds and cliff rocks. Surprisingly, the engineered structures that residents were most aware, the revetment and groins, were only mentioned once each as a preference. There does not seem to be a connection between being aware of the existing built structures (groin, revetment, and cliff rocks) and their preference for them. For example, ten (10) people were aware of the groin, eleven (11) of the revetment and six (6) of the rocks at the base of the cliff but preference for these features was much less: three (3) people wanted the revetment enhanced, two (2) the groin and two (2) the cliff rocks.

Although approximately half of the LH residents perceived a positive relationship between infrastructures when it came to specific hazards, this positive relationship was not mentioned as influencing preference. Only four (4) residents said that their preference was to use both infrastructures when asking for specifics. And, although most believed that the revetment reduces impact from storms and erosion this does not seem to influence preference for this type of engineered structure to be used. Only three (3) people preferred a revetment or seawall as a form mitigation structure. The perception of the natural features shown, especially the dune area, was that the features reduce all hazards. However, dunes were not specifically mentioned by more than one (1) person as a preference, two (2) mentioned their preference for wetland enhancement: the most mentioned natural feature preferred was vegetation. This was also the mostly commonly offered natural feature mentioned when asked about existing features in the area that reduce coastal hazards or impact from coastal hazards. Again, the most salient hazard for the LH residents in the study seems to be erosion.

The strongest responses of mitigation functions were of the revetment and the dune area. And, although there was low interest in the revetment as a preferred mitigation infrastructure, vegetation in the form of seagrasses and trees were preferred natural features (existing and shown in the dune area photo). Interestingly, although both the revetment and dune area had a high response of positive functions in mitigating hazards, built infrastructure was perceived as functioning better, and preferences were mixed among engineered, natural and using both infrastructures.

The cost of the infrastructures, including maintenance, also did not seem to influence preference for infrastructures. The long term and other benefits were mentioned as justification for preference including habitat and recreation, as well as the engineered structures making people feel good and giving the impression that the area is being taken care of.

Unlike some of the other variables, there was consistency in what participants perceived of the function of the infrastructures and what they prefer be used. Even though the built structures are perceived to work better in mitigating hazards, several residents preferred they be used in conjunction with natural features. In the LH study, even though eight (8) people said that built structures work better to reduce coastal hazards and only two (2) people said that natural infrastructure works better, only four (4) specified that they preferred built infrastructure alone. The majority either preferred natural infrastructure or both natural and engineered infrastructure be used in their area to mitigate coastal hazards.

The ancillary benefits provided by natural infrastructure and the perception that the infrastructure work together to mitigate specific coastal hazards were the perceptions that influenced more residents to prefer natural infrastructure alone or in combination with engineered.

5.2 Union Beach

5.2.1 Awareness of Mitigation Infrastructure

Many Union Beach (UB) residents were unable to identify infrastructure in the area that serve to mitigate coastal hazards. A 43-year-old woman who has lived in Union Beach for ten years and prior to that lived in a neighboring town explained, "When I first heard about [this] study I wondered what structures [we] have: don't really think about structures when I think of Union Beach" (12cm102415). Sixty-two (62%) percent of Union Beach residents said they either didn't know of any engineered structures or said conclusively that there are no engineered structures in Union Beach that serve to mitigate coastal hazards. Five (5) participants did not know about engineered structures that exist for purposes of reducing hazards or impact and three (3) said that there were not any. And, a range of engineered structures were mentioned by the rest of the participants, none commonly mentioned: the most mentioned only once or twice: groin, seawall, bulkhead, berm, beach replenishment, even flood gates at neighboring industrial plant. Also mentioned were other mitigation measures such as house and road elevations. Only 15% of participants volunteered how they thought about the functions of the engineered infrastructure they mentioned, and even less, 8%, volunteered an explanation of natural features they were aware of. Explanations about the engineered structure that residents were cognizant of included them not being sufficient:

> "Despite built structures, when we get a severe storm, water will just go over bulkhead" (68-year-old retired foreman who has lived in Union Beach for 58 years, 6jh92515).

More than half (54%) of the UB participants said they did not know about any natural features the reduce coastal hazards or impact from coastal hazards. Those natural features that were mentioned more than once were wetlands and offshore reef/sand bar. One (1) participant mentioned rocks. Unlike Laurence Harbor, dunes and vegetation were only cited once. Seagrass plantings being a part of a berm project was also only mentioned once. No one volunteered an explanation to the functioning of the natural features specifically. Instead they volunteered what they have come to know about natural features:

> "Trying to preserve [natural features]: The reason we have very [limited amount] of the [natural features] is because we filled [them] in 40 or 50 years ago (37-year-old accountant who has lived in Union Beach for 10 years, 11kl102315)

An 86-year-old woman residing in Union Beach for 60 years proclaimed: "They say that when they interrupt [natural thing], like what they did in the Meadowlands that caused more flooding." She also explained both existing infrastructures as not being sufficient to mitigate the effects of recent storms: "Built [structures] weren't sufficient, natural [features] didn't do anything […] water kept coming" (7es92515).

5.2.1.1 Sources of awareness. The main sources of awareness of the engineered infrastructures UB residents were conscious of (before they were shown pictures from the area) were from seeing the structures and several participants said that they came to be aware of the structures from friends/ family and government/ public officials. Three (3) people were aware of the engineered structures they mentioned from family/ friends although none learned about the natural features they mentioned from these sources. Four (4) people that were aware of natural features came to know about them from seeing them. One (1) participant had studied natural features, two (2) learned about them from the government. Likewise, the source of awareness of the built structures and natural features shown in the pictures also came from residents seeing them, not from the social groups, organizations or from studying.

The majority of the participants that knew about some sort of engineered project proposals heard about them from the government, four (4) people became aware of proposed projects from neighbors/ friends. The awareness of natural project proposals was more mixed, with information about the projects coming from the news, neighbors/ friends, or the government. One (1) person heard about the proposed project from an organization another said they sought out information to learn more about it.

5.2.1.2 Awareness of planned projects or proposals. Every UB resident that participated in the study knew about some engineered project or proposal. Close to half were aware of a seawall/ floodwall or the planned USACE (comprehensive) project, that includes a seawall and many exclaimed that it hasn't been done:

> "[They are] supposed to do something [which was] discussed after Hurricane Donna [but] nothing ever happened" (85-year-old retired computer programmer, 9pf92515).
>
> "[USACE] had talked about dredging and put up a retaining wall: nothing came of it" (68-year-old retired industrial plant foreman, 6jh92515).
>
> A few described their understanding of the project(s):
>
> "[Seawall is going to] surround the coast and come up behind [our] home into marshes" (49-year-old accounting supervisor who has lived in UB for 20 years, 5jc91815).

> "Going to put stuff out there like Keansburg" (86-year-old former borough tax collector, 7es92515).
>
> "Project to prevent coastal flooding and wave actions" (37-year-old accountant with some previous construction work experience, 11kl102315).
>
> "[Projects'] emphasis on water dissipation" (50-year-old man who sits on the local planning board, 4ac91915).

Others expressed that they do not know details:

> "Would be able to make a better decision if I knew more about [USACE] project" (37-year old nurse who has lived in Union Beach for 6 years, 1ak91815).
>
> "Don't know details" (86-year-old woman who has lived in UB for 60 years, 7es92515).
>
> "Would have to see proposal" (85-year-old retired computer programmer and computer operator, 9pf92515).

The majority of UB study participants were not familiar with any proposals to enhance natural infrastructure. Projects mentioned, although not more than once or twice, included dune creation, beach replenishment, buyouts, dredging wetlands/ creeks and more natural land:

> "Were supposed to dredge creek, just planted trees" (86-year-old woman who has lived in UB for 60 years, 7es92515).
>
> "Take back the land of areas with repetitive loss" (45-year-old education technology specialist who has lived in Union Beach her whole life, 13jv11215).

A 37-year-old accountant who has lived in Union Beach for 10 years explained his understanding that "There are no natural projects because [they're] not allowed to touch wetlands" (11kl102315).

5.2.2 Perceptions of Mitigation Infrastructures

5.2.2.1 Functions of mitigation infrastructure

Many Union Beach (UB) residents offered that the existing engineered structures do not serve a function in mitigating coastal hazards. When shown a picture of the bulkhead/ revetment, before being asked about the structure and its function in mitigating specific coastal hazards, 85% of Union Beach participants volunteered what they thought about the bulkhead/ revetment: three (3) stating that the built structure “does not do anything”. The most common descriptions of the revetment/ bulkhead offered by UB residents were related to its functions associated with water: eight (8) people said the revetment/ bulkhead either breaks, contains, or directs water. Two (2) participants perceived that the structure is "supposed to stop flooding". Before being probed about the structure and specific coastal hazards, three (3) UB residents offered that that the bulkhead/ revetment reduces erosion. A 49-year-old, who has lived in Union Beach for 20 years and is there because of the community, her job, and being near the beach, offered that the revetment/ bulkhead “won't erode like a sandy beach” (5jc91915). Another resident offered that the structure creates erosion in other areas. Two (2) people considered it not good enough to address coastal hazards: that it is not high enough or doesn’t help much.

However, when probed about specific hazards, the majority said that the revetment/ bulkhead reduces impact from storms. Two (2) clarified their response saying it breaks the force of water. A few residents gave their perspective on the structure saying that it helps: flooding would be worse if the structure wasn’t there or that more of the type of structure is needed:

> “Would be worse if it wasn’t here” (43-year-old graphic artist, 12cm102415).

> “Need more, helped out a lot” (40-year old mechanic and welder that has lived in UB for 6 years, 2ma91815).

Four (4) participants agreed that the ability of the revetment/ bulkhead to reduce impact is dependent on the storm. While four (4) participants believed that the built structure does not reduce impact from storms. An 85-year old man who has lived in Union Beach for nearly 60 years clarified that “during a storm surge [revetment/ bulkhead] will be wiped out” (9pf92515). A 68-year-old woman who has lived in the area nearly as long claimed that “erosion control is only thing [revetment/ bulkhead] is good for” (6jh92515). A little more than half of the UB residents perceived the revetment/ bulkhead to reduce flooding and erosion. Three (3) participants clarified that the structure only reduces flooding to an extent. And, five (5) participants believe that the structure does not reduce flooding. One (1) resident related the existence of the bulkhead/ revetment and its function to its relationship with the nearby wetland clarifying that the structure does not reduce flooding by the wetland.

Although seven (7) of the residents stated that the bulkhead/ revetment reduces erosion, the other participants had mixed responses: four (4) people were either unsure, saying that it depends, or that the structure doesn’t make a difference to control erosion. A 83-year old library assistant who has lived in UB for 59 years described the changes she has witnessed to the area where the bulkhead/ revetment is:

> “Let me put it this way, back in the 1940s you could walk at low tide in front of the bulkhead [….] that is erosion, but [it] happened over a long time. [I] think the bulkhead and revetment stopped it, probably would have been worse [without them]” (10gb101615).

A life- long resident elucidated that the revetment/ bulkhead might actually make sedimentation of the nearby creeks worse:

> "After Sandy creeks are filled with sediment, [revetment/ bulkhead] didn't stop that, actually made it worse" (43-year-old woman who has lived her whole life in Union Beach, 13jv112115).

Another resident clarified that sediment actually gets dragged out from underneath the structure. Two (2) participants said that the revetment/ bulkhead does not reduce erosion.

Sixty-two (62%) of the Union Beach participants volunteered their perception of the function of the groin before being asked specifically about certain hazards. Similar in what was offered of the revetment/ bulkhead when shown the picture before probing about specific coastal hazards, four (4) out of the thirteen (13) participants put forth that the groin "does not do anything" to reduce coastal hazards. Two (2) explained they did not know about its functions. An 85-year-old resident who has lived in Union Beach for 59 years pronounced that because the groin is perpendicular to the beach it doesn't reduce hazards: "[Structure is] vertical to ocean: doesn't protect unless parallel to beach" (9pf92515). Only two (2) UB residents volunteered that the groin reduces erosion and three (3) that it breaks waves.

When probed about the function of the groin the majority of UB residents explained that the groin breaks the waves and more than half agreed that the groin reduces impact from storms. Four (4) residents did not regard the structure as mitigating risk from storms. Two (2) reported they were not sure of the groin's function when it comes to storms.

Study participants from UB were most in agreement that the groin does not serve to reduce flooding. Only two (2) participants said that it does reduce flooding and one (1) person elucidating that the structure breaks waves when discussing the structure and flooding. Two (2) participants said they didn't know if the groin had any role in mitigating flooding.

Only two (2) residents volunteered that the groin reduces erosion before the researcher inquired specifically about erosion, and when asked directly about the groin's erosion mitigation function, UB residents were much less conclusive than those in Laurence Harbor. Only one (1) person distinguished that the structure reduces erosion and two (2) people saying that it depends. One (1) person explained that there is erosion on the other side from the way that water comes in. Six (6) people were either unsure or didn't know how the structure functions associated with erosion. A resident of 10 years who has lived in two different parts of town said she wasn't sure about the groin's function associated which erosion, instead depicted what she has seen: "Other area used to have a beach before Sandy [washed away] and the other side doesn't have a beach" (43-year-old woman, 12cm102415). Four (4) residents believe that the groin does not reduce erosion or make a difference. An 85-year-old explained that there is "nothing nearby to erode […] [the] beach washes in and out" (UB resident for 59 years, 9pf92515).

More than half of the Union Beach residents (69%), when shown a picture of the Flat Creek wetland, volunteered how they think the feature functions, mostly associated with flooding. Six (6) out of the thirteen (13) UB residents volunteered (before being probed about specific coastal hazards) that the wetland increases flooding. And, nine (9) people described the wetland as a place for water to go. Other portrayals of the wetland's function were slowing down water, breaking waves, and reducing wind. Only one (1) participant said that the wetland does not do anything. A 49-year old resident shared her perception that it, "Seems that with normal storms [wetland] would keep water from doing damage to people's properties, with [its] tributaries [it] might slow the water the way the water comes in" (5jc91915). Another resident described that the wetland could reduce the velocity and volume of water: “[Wetland] lets some water in [and] will reduce water if flat [...] water would come straight across and hopefully slow down” (50-year-old alarm system installer and reverend, 4ac91915).

When probed specifically about the role of the wetland and storms, seven (7) UB participants answered that the wetland reduces impact from storms with common themes being the wetland’s role of breaking up water and being a place for water to go. Three (3) of the residents do not believe the wetland reduces impact from storms with one (1) person saying that the wetland may increase the impact from storms, another clarifying that water cannot be stopped. Three (3) people were unsure or said they did not know about the function of wetlands during storms.

When asked directly about flooding and the role of the wetland, only three (3) people responded that the area doesn’t reduce flooding and six (6) had volunteered (before probing) that it increases flooding. A 68-year-old man who serves as the president of the town’s recreation committee contended, “Water needs to stay in [the wetland] area: if water stayed in area, streets would not flood” (6jh92515). Nine (9) of the thirteen (13) participants described the wetland as providing a place for water to go, four (4) residents believe that the wetland directs water and this may be part of its function in reducing flooding:

> “Water has some place to go if [wetland is] left as is, water can spread out." (85-year old retired telecommunications operator and programmer who has lived in UB for 59 years, 9pf92515).

A 45-year old education technology specialist who has lived in UB her whole life offered her general perception of the wetland: “Area would be worse off if it [wetland] wasn’t here" (13jv112115). Two (2) residents mentioned that areas around the wetland have been filled in, especially Schoeler Park, and the negative impacts of that creating more flooding. When describing the wetland area, a 65-year-old retired social worker who has lived in Union Beach for 6 years and before that in a neighboring town for three years said:

> "[Schoeler] Park shouldn't have built: should have been left alone because [wetland] was a 'catch all'" (3ma91815).

Responses were mixed on the role of the wetland in reducing erosion. Six (6) people said the wetland doesn't reduce or make difference in mitigating erosion: it is away from the coast, reduces erosion only locally, and is the first area to erode. Two (2) residents were unsure of a role of the wetland and erosion. Five (5) participants said the wetland can reduce erosion.

Union Beach residents in the study volunteered less about their perception of the dune/ maritime forest area when shown a picture than they did when shown pictures of the wetland or the engineered structures: only 38% of the participants offered a description of how they thought about the natural feature before they were probed about certain coastal hazards. Some common offered descriptions of the maritime forest/ dune area by Conaskonk Point were that it dissipates storm energy and is a place for water to go. Also heard was that the natural feature reduces erosion. Ranges of offered descriptions of the maritime forest/ dune area included that it increases erosion, serves as a berm, doesn't reduce flooding, and that it directs water. One (1) person compared the dune area to the wetland saying it protects better than the wetland. This was not a commonly shared perception, as more people believed the wetland to reduce impact from storms and reduce flooding than did of the dune/ maritime forest area.

When asked specifically, there was a diverse range in residents' perception of the maritime forest and mitigating impacts from storms. There was an equal frequency of response by residents unsure of the natural feature's role with regard to storms, those that believe the natural feature does reduce impact from storms and does not reduce impact from storms, and those stating that it depends (mostly on the storm) if the area reduces impact from storms. A common theme of how the maritime forest might reduce impact from storms was that the area "is a buffer". Also heard was that is "a place for water to go".

More participants (six (6) people) agreed that the maritime forest reduces flooding than perceived a role of the natural feature to reduce impact from storms (only three (3)). The most common explanation was the same that was offered when first seeing the picture of the area before being probed about specific hazards: area is "a place for water to go". Three (3) people said the natural feature does not reduce flooding. Two (2) were unsure. An 86-year old retired tax collector and bank clerk said that if the maritime forest was "too far away from the beach it doesn't make a difference" (7es92515). When asked about the maritime forest area's function regarding flooding, a resident of twenty years mentioned that the area reduced erosion caused by flooding (5jc91915).

Residents were also mixed in responses to how the maritime forest might be related to erosion. A 68-year-old retired foreman who has lived in Union Beach for fifty-eight years, described his thinking about the area and erosion simply stating: "Sand washes away" (6jh92515). Five (5) participants said the maritime forest area doesn't reduce erosion, four (4) said it did, and one (1) said it depends. Three (3) were unsure. Also heard was that the natural feature redirects water and serves as a buffer. A 65-year old woman clarified that the area can work best if not modified by human action: “[Maritime forest] can reduce erosion is left alone” (3ma91815).

5.2.2.2 Benefits and costs. Nine (9) out of thirteen (13) Union Beach residents believe that engineered infrastructure is better than natural infrastructure at reducing coastal hazards or impacts from them. Explanations given by participants including engineered structures being designed to mitigate hazards and able to be put where needed, breaking waves/ surge, serving as a buffer, reducing flooding, reducing velocity of the wind, being more durable/ stronger, and protecting natural features. A unique response heard from a 49-year old woman who has lived in Union Beach for twenty years, was that natural features can't be designed without built structure (5jc91915). A 37-year old nurse who has lived in Union Beach for six years claimed that she believes that built infrastructure is better at reducing hazards only because she does not know the functions of the natural infrastructure (1ak91815).

Two (2) people believed natural infrastructure was better at reducing coastal hazards or impact from coastal hazards explained as "nature knows what to do". Others explained their perception of the natural features in relation to engineered structures:

> “Natural features work better and [are] doing more […] [if we had more natural features] wouldn’t need as much manmade resources” (37-year old accountant, 11kl102315).

A 65-year old woman who lives in UB because of family explained her beliefs that less built structures would have to be undertaken if there were more natural features and that we cannot always be sure what is best:

> “Wouldn’t have to do as much if there were more natural [features] […] nature knows what it needs, man doesn’t always” (3mb91815).

> “Natural [features] doesn’t create hazards when they break” (45-year-old education technology specialist and life-long resident, 13jv112115).

When comparing infrastructures in terms of function one (1) UB resident said that natural and engineered infrastructure have different functions and another said they did not know which was better at mitigating coastal hazards.

Every Union Beach resident from the study except one (a 45-year old, life-long resident who believed money is spent either way, 13jv112115) claimed that natural features have a lower cost or no cost: no materials needed, little to no maintenance, already there, no need for plans, design or labor. Only one (1) person claimed that there is less maintenance required for built structures and three (3) people declared that the engineered structures have a longer-term benefit. And, most UB residents perceived natural features to have a longer-term benefit. Common themes included lasting longer and being self-maintaining and adapting. Other benefits participants claimed were preservation of green space and habitat, nature going where needed and getting better with time.

The ancillary benefits mentioned by study participants fall into three categories: social, economic or ecological. Most of the benefits that participants identified with engineered infrastructure were social (recreation, aesthetics, community gathering place) with a few being economic (attracting visitors).

Ten (10) out of the thirteen (13) participants identified other benefits of the revetment/ bulkhead and all except one (1) participant identified added benefits of the groin. Engineered infrastructure was perceived by residents to have recreational benefits and to look good/ and give a good impression. Other responses ranged from attracting visitors, a community gathering place, and habitat for aquatic organisms. Nine (9) and twelve (12) of the thirteen (13) UB residents perceived ancillary benefits to the wetland

and maritime forest, respectively. The most commonly heard benefits of the natural infrastructure were ecological, mostly wildlife habitat. Residents also mentioned social benefits such as the natural features' beauty and recreation provision. There was focus on the dune/ maritime forest area being a place for recreation and fishing (there is a parking area nearby and more accessible than the dune area in LH).

More than half of participants could not identify any problems with either type of mitigation infrastructure. Those problems that were identified for the engineered structures ranged from garbage, unwanted visitors, being dangerous, conflicting with nature, or the way the structures look. Problems identified of the natural features were safety, garbage, rodents, odors, and unwanted visitors.

5.2.2.3 Relationship between infrastructures. All except one (1) Union Beach resident (who said that it depends on how the infrastructure are built) claimed that both natural and engineered infrastructure could be used to mitigate coastal hazards. Important to using both infrastructures for mitigation is a consideration of how their functions might impact the other. The majority of UB residents (eight (8) of thirteen (13)) affirmed that natural and engineered infrastructure do affect each other's functioning when located near each other. Only one (1) person offered that they do not affect each other. The other three (3) study participants were unsure: "[I] don't think they affect each other at all; in my head I just don't see it" (43-year-old graphic artist, 12cm102415) and one (1) resident indicating that they think they might affect each other.

The majority of those residents that said there was a relationship between the infrastructures perceive it to be a positive one: that they reinforce/ support each other, one (1) person specifying that they enhance each other's functioning. Residents described how they perceive the relationship: two (2) people explained that the built structures channel water to the natural features. Others explained that the built structures that they work together or take pressure off the other and perform the same functions:

> "Natural stops a lot of water, built breaks up water" (76-year-old who has lived in the area for 60 years, 8ms92515).

> "Built [structures] direct water to natural areas that fill up. Wall will push water to a certain area [and] natural features will fill up so everything won't be overwhelmed, especially with a lot of rainfall" (40-year old mechanic and welder who has lived in UB for 6 years, 2ma91815).

> "These three [dune, groin, revetment are] doing the same thing: dissipate energy and prevent flooding" […] "Both [natural and engineered infrastructure] prevent erosion" (50-year old reverend who also serves on the planning board and has lived in UB his whole life, 4ac91915).

Many participants described how they think about the functions of the infrastructures when asked about the relationship between them without making a conclusive statement if the relationship is a positive or negative one: they described how both infrastructures work to mitigate hazards indicating that they can think of them as system without particularly making the connection of how one's function might affect the other's function:

> "It's like a 'water squish ball' [water] goes in one way [and] is blocked and needs to go somewhere else" (65-year old woman who has lived in the Raritan Bay area for most of her life, 3mb91815).

> "Natural processes disperse water behind built" (40-year-old mechanic and welder who has lived in the area for nine years and in a coastal area of Florida for 15 years, 2ma91815).

> "Built would stop erosion […] seawall block[s] water and [the] wetland prevent[s] water from traveling […] water would fill wetlands" (68-year-old retired foreman and the president of Union Beach recreation, 6jh92515).

> "[Built structures] affect ebb and flow of sand" (86-year-old who proclaims to love the Borough and has lived there for 60 years, 7es92515).

Only one (1) UB participant, a life-long resident of forty-five years, offered that the relationship between the infrastructures is negative expressing that engineered structures can cause damage to natural features: “Manmade structures cause issues to natural protective areas […] [they] redirect water [and] more things get damaged” (13jv112115). She conditioned that if the infrastructures are planned out properly they can support each other.

When asked if there was an advantage (a benefit) of natural features on built structures, similar to LH, perceptions in UB were divided: six (6) participants said that there is an advantage to the built structures from the natural features, while six (6) said there was not. Explanations included that built structures would work less if natural features are there: natural features slow things down. A 68-year-old man who is actively involved in town activities described vegetation around the built structures as being protective of them: “Foliage helps stop erosion” (6jh92515).

Participants were mixed in opinion about an advantage of the built structures on the natural features: five (5) said there is an advantage, four (4) said there is not and three (3) said they did not know if there was an advantage or not. Explanations of an advantage of built structures on natural features included that built structures can slow down water, reducing flooding of the natural features, and that natural features cannot mitigate hazards alone. Another explanation heard was that built structures protect natural features:

> “If [we] had more of the manmade [structures] would be better for protection and [with] natural behind it natural features would be protected: [built structures were] made for that” (50-year-old reverend and alarm system installer, 4ac91915).

> “Need dunes and something to protect them […] Bulkhead could benefit dune if close by” (86-year-old retired borough tax collector, 7es92515).

> “[Built structures] prevent water from flooding natural areas, but don't know if built structures would protect natural” (83-year-old library assistant who has also substitute taught and served as a laboratory technician, 10gb101615).

One explanation of a disadvantage of the built structures posed by a given by a 65-year old retired social worker was that built structures take away the ability of natural features to "do their job". She also explained the built structures: “upset the ecosystem: that is why we have all these problems, look at all what has gone on […] trying to hold back something that is supposed to naturally flow” (3mb91815).

There was less of a range of residents' perception of the relationship between infrastructures when asked specifically about certain coastal hazards. The majority of study participants believed that the infrastructures support each other during storms. Only one (1) participant perceived the infrastructures to contradict each other's functioning during a storm. Two (2) people said there the infrastructures do not affect each other’s functioning during storms. Three (3) were unsure. Explanations included that built structures protect the natural features from eroding, that the infrastructures work together as the built structures break up waves and the natural features absorb water and control some flooding, similarly, that the dune area can slow down water during a storm before getting to the built structures.

The UB residents in the study were more prone to not perceive a relationship between infrastructures regarding flooding and erosion then during storms: six (6) residents said the infrastructures work separately associated with flooding and five (5) said they work separately associated with erosion.

> “[They] could put a bunch of built structures, the natural features will work the same” (40-year-old mechanic, 2ma91815).

> "[There is] no correlation between the groin and dune" (68-year-old man who has lived in Union Beach for 58 years, 6jh92515).

> "Don't think [engineered structures are] pushing erosion elsewhere except a little from groin, but wouldn't affect dune" (50-year old, life-long resident, 4ac91915).

One (1) person explained that water comes in a different place, another said that neither infrastructure has an influence on flooding. Two (2) people explained that natural features do not have influence on the erosion around the built structures.

Similar to the relationship during storms one (1) person said that the built structures and natural features contradict each other when there is flooding and two (2) residents believed the infrastructures contradict each other in erosion mitigation. One (1) person explained that manmade structures cause more erosion. Four (4) people said that the infrastructures can support each other in mitigating flooding. Only two (2) said so of the infrastructures regarding erosion: built structures protect the natural features from erosion.

A few participants further explained how they think about the infrastructures when discussing the relationship:

> "Every time you put something manmade in you don't always know the impact" (37-year-old woman who has lived in the Raritan Bayshore area all of her life, 1ak91815).

> "Problem goes somewhere else […] Water has nowhere to go: [wetlands] used to clean itself out. Problem is [we] overbuilt and nature [has been] taken away" (65year-old woman, 3mb91815).

> "[USACE project at] Route 36 to stop flooding on highway created more flooding in Union Beach: solved one problem, created another. Now having flooding in areas we never did by taking away areas that were meant to absorb the water now no longer able to absorb" (Life-long female resident of 45 years, 13jv112115).

> "[We] wouldn't need as much built structures [if had more natural features]" (37-year-old accountant who has lived in UB for 10 years, 11kl102315).

5.2.2.4 Perceptions associated with preferences. Similar to residents of Laurence Harbor, UB residents stated their preferences for given structures or features due to their perceptions of them working better.

> "If the built [structures] went around more (they stop at a certain point), […] [if they] extended more, it would protect land from erosion" (37-year-old nurse, 1ak91815).

> "If they built the dunes along Brook Ave and along the beach, less water would come out onto the streets" (43-year-old woman who has lived in two different locations in Union Beach, 12cm102415).

> "Wetlands and creeks are like plumbing: during normal storms [they] would work, give water a place to go, [and water] goes back out if [they were] cleaned out" (50-year-old reverend who has lived in UB for his whole life, 4ac91915).

There was not as much of a range of explanation of the preferred structures and features as among the responses from Laurence Harbor residents. Common among the responses by UB residents was a justification of preference for specific structures or features because of knowledge of them working well in other places:

> "Manmade wall good idea: seen it firsthand that we need it: water would have gone elsewhere, like in Keansburg [who has a] flood gate/ wall" (40-year-old mechanic and welder, 2ma91815).

Also heard among UB residents was a trust for engineers and that something needs to be done:

> "Need something built that stop[s] water from coming in" (68-year-old retiree who has lived in Union Beach most of his life, 6jh92515).

> "Things need to be done [to address] street flooding: [there is] regular flooding [of] Union [and] Broadway, anything that would help that area is important" (65-year-old retired social worker, 3ma91815).

An 85-year-old retired computer operator and programmer (9pf92515) explained that each type of infrastructure serves a separate purpose in different locations. And, a 37-year-old accountant who has lived in Union beach for 10 years (11kl102315) said that the wetlands cannot be enhanced. Another unique explanation, given by a 45-year-old woman (13jv112115) who has lived in Union Beach her whole life, was that natural infrastructure does not create hazards when they break.

The strongest perceptions of benefits to the community of preferred infrastructure in Union Beach were the infrastructures having the ability to protect the community. Residents believe that if their preferred improvements were made there would be less property damage, loss of life, less flooding, and potential to protect the community from having to raise houses, even lower flood insurance. Other community benefits mentioned by residents were that the preferred infrastructures would provide longer-term benefit, aesthetic improvement, and recreation, are more resilient, and make community safer.

UB residents generally had positive perceptions of the proposed engineered projects they knew about, two (2) were skeptical, claiming that they either did not have enough information, or saying it depends on where, when, and how the project would be done. Also heard was concern of flooding elsewhere and the age of the design. An 83-year-old library assistant summed it up that something needs to be done and she will be able to form an opinion about it after it is done claiming: “Seeing is believing” (10gb101615).

No one in Union Beach that knew about natural enhancements whether dunes, buyouts, or work on wetlands were skeptical of the proposals. A life-long resident recognized that although buyouts would result in loss of tax ratables the taking back of land “lets nature take its course [and] would be more visibly appealing” (45-year-old woman, 13jv112115).

5.2.3 Preferences for Mitigation Infrastructure

Like Laurence Harbor, UB residents had a mixed preference for type of mitigation infrastructure they would like to see for the future: four (4) participants preferred natural features, five (5) preferred engineered and three (3) preferred both, only one (1) participant was unsure.

> An 86-year-old woman who has lived in Union Beach for 60 years claimed that “everything is built, don’t have enough open space: need open space” also claimed that Union Beach “need[s] dunes and flood gate […] need [the Army Corps] to start” (7es92515).

> A 37-year-old female resident who has lived in Union Beach for 6 years, as well as other areas of the Raritan Bayshore, admitted: “I don’t know what would help, not familiar what natural features could help during times of coastal flooding”. She generally expressed: “If we had a way to enhance the natural features, working with Mother Nature instead of against it” (1ak91815).

> “If we had more built structures we would be better off” (76-year-old woman and resident of 60 years, 8ms92515).

Union Beach residents said that both infrastructures should be used for mitigating hazards. A justification by two (2) residents was that the natural features and built structures are already present. Three (3) residents clarified that both infrastructures should be used only if "done properly". An 85-year-old man who has lived in Union Beach for 59 years said that "protection should be first priority" (9pf91515).

The specific structures and features that residents preferred ranged more than those preferred by residents of LH, and more often than LH, some preferences were only mentioned once: beach replenishment, beach regrading, rocks, wetland enhancement, filling the wetlands, even creating a harbor/ marina in the wetlands.

> “Nothing can be done with marsh other than filling it” (43-year-old graphic artist who has lived in Union Beach for 10 years, 12cm102415).

Two (2) residents said they did not know what they would prefer. An 85-year-old retired clerk and computer programmer said he "Would have to see proposal/ options" (9pf92515). Some residents were unable to give specifics of types of natural or engineered infrastructure they would prefer and just generalized: "something along beach front", "whatever engineers come up with", or "something to direct water elsewhere". Union Beach residents more than once mentioned dredging creeks and maintaining the wetlands, creating berms or dunes as preferred mitigation actions.

> "Do something to keep water (in wetlands) so streets would not flood […] something along the beach front to stop water coming in, dredge creeks lower, put up retaining wall: got to do something" (68-year-old retired foreman living most of his life in Union Beach, 6jh92515).

The most common engineered structures that were preferred were a seawall/ floodwall and flood gate:

> "Think the project in mind is best for real protection" (49-year-old accounting supervisor for a home builder, 5jc91915).

Three (3) people said there was nothing existing they would enhance. An 85-year-old man living in Union Beach for nearly 60 years said: "I don't know how you could have more [of either infrastructure]" (9pf92515).

5.2.4 Synthesis

Union Beach residents that participated in the study had a low awareness of existing infrastructure: the groin, bulkhead, dune, and vegetation were only mentioned once and wetlands three (3) times among the study participants. Eight (8) participants either said that they were not aware of any built structures to mitigate coastal hazards or exclaimed that there are no existing built structures serving that purpose. Seven (7) participants were unaware of any natural features that reduce hazards or impact from coastal hazards. Three

(3) residents, when shown pictures of the revetment/ bulkhead, and four (4) when shown a picture of the groin, before being asked about specific hazards, exclaimed that these structures do not do anything to mitigate coastal hazards. This was not the case for the natural features shown in pictures: no one offered that the natural features do not do anything.

Even though salience of existence of mitigation infrastructures was low among the Union Beach study participants, when probed about the functions of the existing structures and features that the participants saw in the pictures, these residents were able to describe how they perceived the structures and features to function. There was a majority consensus on the mitigation functions of the revetment mitigating all hazards, of the groin mitigating impacts from storms, and of the wetland reducing impact from storms and mitigating flooding. The majority of the UB study participants were also in consensus that the groin does not reduce flooding.

The coastal hazard that UB residents had the most mixed responses over was erosion: there was a range of perceptions of the functions of the maritime forest area, wetland, and groin in mitigating erosion. Union Beach residents also had a range of perceptions about the natural features, especially how maritime forest area functions during storms and in mitigating erosion and how the wetland functions associated with erosion. Given these mixed perceptions on the natural features' functions and despite the range of perceptions of the groin mitigating erosion, the majority of UB participants concluded that engineered infrastructure is better at reducing coastal hazards than natural infrastructure.

The most often volunteered explanations of the existing structures and features shown in the pictures were associated with water. More than half of the residents offered that the revetment contains or breaks water and that the wetland is a place for water to go. Just under half of the residents volunteered that the wetland increases flooding and thirty percent of the UB participants offered that the maritime forest area is a place for water to go.

Union Beach residents were able to think about the infrastructures as having an effect on each other. The majority residents explained the relationship between the infrastructures to be a positive one: that the infrastructure support each other's functioning. This was consistent with their perception of their relationship during storms not the other hazards of erosion and flooding where the more people claimed there is no relationship. When asked about advantages of the infrastructures on each other, UB residents were divided both ways. UB residents had mixed preference for type of infrastructure with a little more than a third preferring either engineered infrastructure or natural infrastructure and a little under a third preferring both infrastructures to be used for mitigating coastal hazards.

Connection among themes

Several residents volunteered that the revetment/ bulkhead and groin do not do anything related to coastal hazards. When probed about specific hazards, even more residents claimed that these engineered structures do not reduce erosion or flooding nor reduce the impact from storms. More people replied that the revetment/ bulkhead reduces erosion then those that volunteered this function. Similarly, for the maritime forest, more people answered that the area reduced erosion than offered so. However, more people volunteered that the wetland increases flooding than answered that the wetland does not reduce flooding when probed. Conversely, for the other salient functions of the natural features, such as dissipating storm energy and being a place for water to go, the answers given when probed were of the same frequency as those that were offered.

Even though a several residents volunteered that the engineered structures discussed do not reduce coastal hazards and confirmed this when asked directly about certain hazards, engineered infrastructure was still perceived to work better than natural infrastructure. Residents were divided on the functions of natural features in mitigating coastal hazards (except for the wetland mitigating the impacts from storms and mitigating flooding). The revetment/ bulkhead was perceived by half or more than half of the participants to reduce all the coastal hazards discussed, where the groin was only perceived to reduce impact from storms by half of the residents in the study.

Union Beach residents generally perceive a positive relationship between infrastructures when it comes to storms, not flooding or erosion. The perception of a synergistic relationship between the infrastructures during storms does not seem to influence preference as only three (3) people stated their general preference was to use both types of infrastructure. Although most UB residents in the study perceived the function of the revetment/ bulkhead to reduce coastal hazards, only two (2) mentioned enhancing the existing bulkhead. The majority of UB residents only perceived the groin to reduce impact from storms and only two (2) people preferred it to be enhanced and one (1) person wanted more groins. The majority of residents believed that the groin does not reduce flooding. Again, the salient coastal hazard is flooding in Union Beach. There was less focus on the role of the maritime forest in mitigating coastal hazards, similarly there was no specified preference to enhance the area. There were stronger public perceptions of the wetland playing a role in mitigating flooding and consequent preference by a number of participants to address the wetland through enhancement or dredging.

Although several UB participants agreed that the infrastructures have benefits other than those associated coastal hazards, only a few participants mentioned benefits such as aesthetics and recreation when justifying their preference for specific structures or features. The costs of building, enhancing or maintaining the infrastructures do not seem to influence preference. Although nine (9) participants from UB said that engineered infrastructure works better to reduce impact from coastal hazards, when asked about preference, five (5) people specified preference for built structures and three (3) people said they preferred that engineered infrastructure be used in combination with natural infrastructure to mitigate hazards. The preference for the use of natural infrastructure seems to be more related to other benefits than just working better as only two (2) people said that natural infrastructure works better to mitigate hazards, four (4) stated preference for natural features to be used. Although the perception of function of the mitigation infrastructure was the most common explanation for participants' preference there were other reasons why there was a discrepancy between the number of participants that said the engineered infrastructure works better and those that preferred it be used alone. The perception that influenced the preference to use either natural infrastructure alone or in combination with engineered included that the infrastructures work together/ complement each other.

5.3 Common Emerging Themes

There were some themes that emerged from data that were common to both study areas that were not particularly expected.

5.3.1 Salience of Coastal Hazards

An ancillary theme to the research questions was residents' awareness of the problems associated with living on the coast: for Laurence Harbor, the most salient coastal hazard is erosion. Laurence Harbor residents recognized this hazard, explained how they perceive the problem, and the urgency of addressing it.

> “Whatever erosion is already done […] [but] something needs to be done” (24-year old secretary, 12cm11715).

> “Where ever you have water you have erosion” (64-year old retiree who has spent his whole life in Laurence Harbor, 7rk102415).

> “Water is getting higher, getting more erosion and more silt in other areas, water doesn’t have a place to go” (61-year-old chef and life-long resident, 4kh292715).

> “Contour and height of shore has changed post-Sandy: water comes up higher now” (62-year-old retired telecommunications researcher and developer, 1dw92515).

> “Might be too far gone [from erosion] to get benefit from natural features alone” (42-year-old chief operations officer of a wholesale company, 9sm102415).

> “Should reinforce cliff before it collapses” (72-year-old retired woman, 14df112015).

In Union Beach, there was an emphasis among residents on water and flooding. Residents’ expressed their experience with water:

> “Got to point where every time there was storm at sea [the water] would come in a little bit further” (68-year-old retired foreman, 6jh92515).

> “Flooding comes from storm sewers [which are] never cleaned out: no stop gap for water from storm sewers” (86-year-old retired town tax collector, 7es92515).

> “It’s like a 'water squish ball' [water] goes in one way is blocked and needs to go somewhere else” (65-year-old retired social worker, 3mb91815).

5.3.2 There for a Reason

Residents justified their responses to the questions posed to them by describing the existing structures and features having a purpose. For engineered infrastructure, this was an explanation of the decisions that have been made. There were a number of residents in both study areas that explained their reasoning: Residents said of the engineered structures:

> "[The groin was] put there for a reason" (73-year-old man from Laurence Harbor, 2kh92715).
>
> "Built [structures] were put there for a reason and seem to be doing a good job" (72-year old woman from Laurence Harbor, 14df112015).
>
> "That is why it [revetment/ bulkhead] is done like this [to stop flooding]" (76-year-old woman from Union Beach, 8ms92515).
>
> "Built structures were made for protecting natural features" (50-year-old man from Union Beach, 4ac91915).
>
> A 67-year-old retired administrator of a legal department who has lived in Laurence Harbor for 12 years reasoned: "Town would not exist without built structures: Sandy demonstrated why they were originally built". He also recognized the action of planting vegetation to deal with erosion: "Plants [at the dune area] were brought in to control erosion" (11gm11615).

Residents volunteered their understanding of the "purpose or reason" for the existence of natural features. A 50-year-old firefighter from Laurence Harbor believed that the dune exists to mitigate flooding:

> "Purpose of dune is to reduce flooding" (10bm11615).

Two residents in Laurence Harbor, a 61-year-old chef and a 30-year-old stay-at-home mom, provided the same value statements:

> "[Wetland] is the way it is supposed to be" (4kh292715, 3tb92715).

Similarly, two residents (a 65-year-old retired social worker and 40-year-old mechanic/ welder) from Union Beach, specifically stated that natural features are there for a reason without further description of them:

> "[Wetland is] there for a reason" (3mb91815);

> "Natural features are there for a reason" (2ma91815).

A 37-year-old male accountant from Union Beach went further and clarified his perception that natural features work better and do more than engineered features:

> "Natural features [are] there for a reason [and] work better and doing more" (11kl102315).

Another Union Beach resident, a 45-year-old education technology specialist, reasoned that there needs to be a consideration of the purpose of natural features:

> "Need to keep in mind what nature is trying to give us, for example, consider why a sand dune was created [was either] by nature or [as the] result of manmade [activities]: [need] understand why it's there" (13jv112115).

A couple of residents used the explanation of "reason" to explain the relationship between both infrastructures as well:

> "[Built structures and natural features] coexist for a reason" (40-year-old mechanic and welder from Union Beach, 2ma91815).

> "Why they [natural features and built structures] were put there in the first place [to be used together]" (83-year-old library assistant from Union Beach, 10gb101615).

5.3.3 Governance and Decision-Making

Another emerging theme was of attitudes towards governance and decisions, especially engineering decisions. Many residents admitted that previous decisions have been poor and resulted in negative consequences:

> "[When] man touches something, he screws up" (64-year-old retired man from Laurence Harbor, 7rk102415)

> A 61-year-old chef from Laurence Harbor described his attitude towards previous decisions in value statements: "If they would just leave things alone the way it is supposed to be […] Things get screwed up when man tries to fix things: should let nature take its course" (4kh292715).

> A 30-year-old stay-at-home mom from Laurence Harbor gave her opinion of engineered decisions by defining: “Engineering is putting things where they are not supposed to be” (3tb92715).
>
> Another opinion about previous decisions came from a 61-year-old life-long resident of Laurence Harbor: “[I have] seen what has happened: screw with nature and you are going to lose” and he furthered: “Built could have been done differently” (4kh292715).
>
> “[I] need to know what [the proposed USACE project] is going to do to upset the natural landscape and environment, every time you put something manmade in you don’t always know the impact, would like to know about the environmental impact before I make a decision” (37-year-old nurse from Union Beach, 1ak91815).
>
> A 65-year-old retired social worker from Union Beach gave her opinion of the decision-making process of one of the engineered structures: “[Revetment/ bulkhead] was not thought out” (3mb91815).

A life-long resident of Union Beach recalls the effect of a decision to fill in an area that used to be wetlands resulting in more flooding: “Ever since Schoeler Park was created and houses built [in area], even with basins, [area] has more flooding: changed the flow of water”. This 45-year-old woman who has lived her whole life in Union Beach cautioned: “We learn more in retrospect: have to be mindful of what was great ten years ago […] [projects] need to be reevaluated frequently” (13jv112115).

The role of governance, decision makers, and how decisions are made were described and meaning was attached to those decisions by study participants:

> “Preserving natural [areas] comes at a political cost: politicians need to show they are doing (building) something” (A 44-year-old city planner from Laurence Harbor, 8kh3102415).
>
> “[There is a] reason why authorities will not let the area [dune/ maritime forest] be built on” (A 32-year-old software engineer from Laurence Harbor, 5pv101615).

A 62-year-old retired telecommunications researcher from Laurence Harbor resident perceived that engineered projects are pursued because government officials are more interested in them: “Large [engineered] projects attract interest and commitment from officials versus natural replenishment” (1dw92515). A 30-year-old stay-at-home mom and resident of LH for 7 years expressed her opinion of why certain decisions are made: "[Cheapest solution] is not keeping up with infrastructure, just leaving it, waiting years and things crumble: if not a wealthy part of town [they] do the fastest and cheapest solution."" (3tb92715).

There was also a recognition by some of the residents that experts (mostly engineers) make the decisions and there was a deference to those decisions. A 72-year-old retired resident of Laurence Harbor, in addition to giving her perception of the engineered infrastructure, deferred to the designers of the structures: “I assume jetties are there to control flooding […] [I] assume they know what they are doing […] “Hopefully [engineers] know what they are doing and took [the relationship between infrastructures] into consideration” (14df112015). A 73-year-old retiree from Laurence Harbor, in discussing his preference for future projects, recognized that it is the engineers that will present the options, and that he could not make a decision because he didn’t know what the structural mitigation options are: “Don't know what engineers have planned” (2kh92715). A 83-year-old library assistant from Union Beach, indicating that her knowledge is limited said, “You should talk to engineers, they know more” (10gb101615). Another Union Beach resident, when talking about her knowledge of the wetland’s function regarding flooding, referred to what she has heard and deferred her understanding claiming that she was not an engineer: “They say that when they interrupt [a natural thing], like what they did in the Meadowlands, that caused more flooding, but I don’t know, I'm not an engineer […] [They] don’t do anything unless an engineer sets it up.” (86-year old retired town tax collector and bank clerk, 7es92515). When talking about the relationship between the infrastructures she deferred to scientists' knowledge: "Need an ecologist: there must be some way to do [engineered projects] in concert with nature that is effective"

> "I don't know how [the groin works associated with erosion], I'm not an engineer" (83-year-old library assistant and former substitute teacher and lab technician of Union Beach, 10gb101615)

A 49-year-old accounting supervisor from Union Beach, when talking about the relationship between the infrastructures, spoke of the decision-making process and expressed her hope that the relationship between the engineered structures and natural features was considered during the design process of the existing structures: "Think town would have done scientific research how they work together and come up with a design for jetty and wall […] the natural features already in the area were probably taken into consideration." When asked about the benefits of the infrastructures on each other's functioning she deferred to scientists: "Scientific people would have to determine the advantages." And, when asked if was anything new she would like to see for Union Beach said she did have enough scientific knowledge to come up with something: "I can't propose new project, I don't know enough about science and coastal waterways" (5jc91915).

> "That is what engineers are there for: they'll come up with something" (40-year-old mechanic and welder from Union Beach, 2ma91815).

A few participants made statements about the governance process. A 42-year-old chief executive of a wholesale company who lives in Laurence Harbor, after talking about what she would prefer be done with the beachfront area to mitigate coastal hazards, offered a governance conflict in decision-making: "[One problem is the] dual ownership and responsibility of park and cliff area between county and town" (9sm102415). A 67-year-old retired administrator from Laurence Harbor also after discussing his preference for future projects offered that: “[Projects] need more coordination and federal support” (11gm11615). And, a 68-year-old retired foreman active in Union Beach’s recreation programs suggested that maybe if there was more information and public involvement, projects to enhance natural features would come to fruition: “[There is] not enough public information, people don’t get involved” (6jh92515).

5.3.4 Importance of Perception

Significant to the subject of this research, perception of mitigation infrastructure was directly mentioned by a few residents. A 44-year-old city planner who lives in Laurence Harbor recognized that having engineered structures can lead to a belief that the area is being protected, or at least invested in: “[Groin gives a] perception that area is being taken care of.” He also believed that: “[Having both natural and engineered structures present] keeps people engaged, [providing] education and awareness” (8kh3102415). Similarly, a 65-year-old retired social worker from Union Beach who believed the groin to serve no function in reducing coastal hazards claimed that the structure is only “for show”: “I think it is just a "show piece", a very nice one, but that is all it is” (3mb91815). A 45-year-old woman from Laurence Harbor recognized that the public perception of the engineered infrastructure aids in a feeling of safety: “Built structures provide comfort [to residents] […] make people feel more secure” (9sm102415).

5.3.5 Lack of Contemplation About Mitigation Infrastructures

An emerging theme most relevant to the research question on public awareness of mitigation infrastructure is the public’s previous contemplation of the research subject, that is the role of mitigation infrastructures and their relationship to each other. Although residents were not asked directly if they had thought about the infrastructures prior to their participation in the study, a number from both study areas offered during different parts of the interview that they have not thought about the topics being discussed.

> "Didn't think about this [dune] area when asked about natural features" (55-year-old warehouse worker from Laurence Harbor, 6dh102415).

A 44-year-old city planner who did perceive an advantage of natural features on built structures prefaced his response by saying: "Oh, that's interesting, I don't usually think that way" (8kh3102415). A 83-year-old library assistant who has lived in Union Beach for nearly sixty years, when talking about the natural features said a few times that she hadn't thought about them: "Never really gave any thought to [the wetland]" (having the same response when asked about the wetland and mitigating flooding as well as when asked about the benefits of the natural feature) and when shown the picture of the dune/ maritime forest offered: "I never paid much attention to [the area]" (10gb101615).

A couple of residents admitted that they could not give an opinion or didn't have answers to some of the questions because they haven't contemplated the infrastructures mitigation functions.

> "Never thought about wetlands, not sure I have an opinion" (62-year old retiree that has lived in Laurence Harbor for 6 years, 1dw92515).
>
> "Don't know about [the groin]: haven't thought about it much" (32-year-old software engineer from Laurence Harbor, 5pv101615).
>
> "Seen high waves bounce off jetty, so guess they would [affect each other], but never really thought about it" (72-year-old woman who has lived in Laurence Harbor for 37 years, 14df112015).
>
> A 43-year-old graphic artist resident in Union Beach for 10 years admitted that she "never really thought about [their preference between natural and engineered infrastructure] before Sandy, [but that Sandy] changed [her] opinion" (12cm102415).

And, of a similar sentiment, a couple residents recognized that recent experience has made them think more about coastal hazards and mitigation.

> "Never thought about coastal hazards until Sandy, seen storms erode but never saw things erode like after Sandy: realized erosion is happening, just don't see it, never thought about it that way: biggest issue is erosion" (55-year old woman from who was born in Laurence Harbor and lived most of her life there, 6dh102415).

> "Never really gave much thought, but got to point where every time here was storm at sea would come in a little bit further, something has to be done" (68-year-old man whose lived in Union Beach for 58 years, 6jh92515)

A Laurence Harbor resident of twenty years ended the interview by concluding: "You've given me a lot of things to think about that I don't usually spend time thinking about" (48-year-old manager, 13jw11715).

CHAPTER 6

DISCUSSION

Analysis of the interviews conducted with residents in Laurence Harbor and Union Beach reveal several similarities as well as important differences in public awareness and perceptions of coastal hazard mitigation infrastructure. This chapter focuses on the similarities in coastal residents' perspective of mitigation infrastructure and the differences between the two study areas with differing public sensibilities toward coastal hazards. The public sensibilities of coastal hazards are dependent on what their community experiences on a frequent basis as well as the impact from a recent disruptive storm. The findings of this study should be put into context of most relevant coastal hazards the two study areas face.

Most of the development of Laurence Harbor is on high ground, outside of flood areas; flooding only exists in small pockets of the community. Coastal erosion is the hazard that Laurence Harbor faces which is further amplified by storms. Cliff reinforcements with rocks, the stone revetment, and number of groins have been built to address erosion. Superstorm Sandy aggravated the erosion of the cliff and caused some damage to the existing engineered mitigation structures. The damage, mostly to the revetment, caused concern over the potential spread of the contamination of the structures. Laurence Harbor residents are very aware of the Superfund activities and concerned about the lead contamination along their beachfront. In Union Beach, a low-lying community, all of the development is in flood-prone areas. Flooding is frequent and occurs during high tide.

Storms amplify this hazard. Superstorm Sandy devastated Union Beach from massive flooding from storm surge amplified during a high tide.

The salience of and importance in addressing these most pertinent coastal hazards was an emerging theme among the two study groups: erosion in Laurence Harbor and flooding, especially flooding resulting from storms, in Union Beach. What was volunteered by participants before the researcher probed about specific coastal hazards indicates what is pertinent to them. Laurence Harbor residents more often volunteered information about the structures and natural features related to erosion, whereas Union Beach residents more often volunteered descriptions of the infrastructures related to their role in mitigating flooding and the impacts from storms. Laurence Harbor residents were more attuned to the functions of existing infrastructure in mitigating erosion then those in Union Beach. Residents in Union Beach were less in agreement about the functions of the infrastructures in mitigating erosion and erosion was not a common theme in what Union Beach residents offered. Flooding and the role of infrastructures in moving water was more common in Union Beach than Laurence Harbor.

The research findings show that in a community that has been experiencing coastline erosion and flooding in certain areas, and impacted thusly during coastal storms, Laurence Harbor, the public awareness of existing mitigation infrastructure is high, understanding of the functions of natural infrastructure is consistent with that of scientific understanding, and perception of a synergistic relationship between infrastructures is highest for the hazards of storms and erosion. In a community experiencing frequent flooding that is amplified and community-wide during coastal storms, Union Beach, there is lower awareness of mitigation infrastructure, less consistent understanding of the functions of and relationship between mitigation infrastructure, especially related to erosion, with that of scientific knowledge.

6.1 Coastal Residents' Awareness of Mitigation Infrastructure

The coastal areas of Union Beach and Laurence Harbor were chosen as cases for study because of the existence of coastal hazards, especially the effects of recent coastal storms. It was expected that the experience of the most recent storm event, Superstorm Sandy in 2012, would have raised awareness of mitigation interventions such as engineered structures and/ or the role of natural features in mitigating coastal hazards, especially in Union Beach. The significance of Superstorm Sandy did influence a few residents who mentioned that they had not thought about coastal hazards or mitigation before that event. It was unexpected that there would be such a difference between the two study groups in their awareness of existing mitigation infrastructure.

Residents' awareness of existing infrastructure, both natural and engineered, was greater in Laurence Harbor than Union Beach and the awareness of proposals for engineered projects was greater in Union Beach. Ninety-three (93%) of Laurence Harbor residents were aware of existing engineered infrastructure and 86% of natural infrastructure. Conversely, only 38% of Union Beach residents were aware of any built structures and 46% were aware of natural features that they thought served to reduce coastal hazards. Nearly all Laurence Harbor residents were able to mention at least one engineered structure and natural feature they thought served to reduce coastal hazards or impact from coastal hazards. Many mentioned engineered interventions that occurred before Sandy. The most salient natural feature for hazard mitigation mentioned by Laurence Harbor residents was vegetation. In Laurence Harbor, there was high awareness of the revetment and discussions to address the contamination of the structure and in Union Beach, there was awareness among the residents about the USACE engineering project that has been on hold and the mitigation actions not taken before Sandy. It was surprisingly that in Union Beach, an area with such damage from Superstorm Sandy, there was such low awareness among residents of the mitigation infrastructure in the area.

Laurence Harbor residents' high cognizance of vegetation as a natural feature that mitigates coastal hazards is most likely due to the high salience of erosion. It is hypothesized that the higher awareness of dune area among Laurence Harbor residents is not only due to their concerns over erosion, but the residents' exposure to that natural feature. The dune area in Laurence Harbor is at the end of a walking trail that is part of Laurence Harbor's waterfront park where the dune/ maritime forest area in Union Beach is part of the western beach access to Conaskonk Point, mainly used by fisherman. The lower awareness of existing engineered structures among Union Beach residents seems to be a result of the fact that the coastal hazard that residents are most concerned about, flooding, is not strongly mitigated by the existing structures. Laurence Harbor residents' high awareness of engineered infrastructure may be due to the pertinence of these structures as part of the Superfund site.

Recent mitigation work completed in Laurence Harbor was also raised by residents, many mentioning the installation of "geotubes" and the rock reinforcement of the cliff. Laurence Harbor residents also described offshore shellfish beds as natural features to mitigate coastal hazards. These were examples of mitigation structures or features that residents were aware of that were not the subject structures/ features[21]. A few residents in

[21] The subject interventions were those discussed in the interviews through the use of photos (revetment/ bulkhead and groin) chosen since they were common to both study areas.

both study areas also mentioned beach replenishment as an engineered feature and subject that was not introduced by the use of the photos. Other than two people in Union Beach who mentioned a berm and one person who mentioned the flood gates at a nearby industrial facility, there were no other physical mitigation structures that Union Beach residents were aware of then those shown in the pictures.

In addition to being more aware of existing mitigation infrastructure, Laurence Harbor residents were more willing to give explanation of the infrastructure they were aware of than Union Beach residents. Laurence Harbor residents more frequently volunteered what they think about the functions of engineered and natural infrastructure they were aware of than did participants from Union Beach. This may be a result of Laurence Harbor residents contemplating the functions of these infrastructures function as they contemplate the remediation of their waterfront. The less frequent offering by Union Beach residents of descriptions of the infrastructure they were aware of may be a result of limited pre-contemplation of the structures and features. Of the few Union Beach residents who were aware of natural features in the area that serve mitigation functions, none offered an explanation of the natural features' function. Instead, those Union Beach residents that identified natural features when asked about existing features in the area described how they came to know about them. It was only once Union Beach residents were shown pictures of natural features that they offered how they perceived them to function.

Despite the lower awareness and less frequent descriptions of existing mitigation infrastructure, Union Beach residents' higher awareness of engineered project proposals was expected, since the USACE project was recently announced at the time of the study and had been in the works for over a decade (some residents recalled historical discussions over the proposal). Even though there was some awareness of the engineered project proposal, most residents could not give details of the project. There was only limited knowledge of the extent of the design. In Laurence Harbor, there was a heightened awareness of the revetment which is part of a Superfund site and much discussion on what should be done with the structure. Stakeholder discussions still continue as to what might be done with the structure in terms of remediation, and not many discussions directly related to improving the engineered structures for reducing coastal hazards.

How people know about the natural features and built structures is important in framing their explanations of the infrastructures. Many participants integrated how they think about and have come to their perceptions of the infrastructures. The majority of study participants' understanding of natural and engineered infrastructures is based on common sense or witness heuristics that result in understanding of natural features being a place for water to go or acting as a sponge or a stone structure breaking waves. Although the majority of the awareness of engineered structures that residents in both study areas were familiar with came from seeing the structures, they also came to become aware through other means such as from media, public officials, and through social interactions such as friends, family, colleagues, or organizations. Only Laurence Harbor residents also reported becoming aware of the engineered structures through studying them, whereas no Union Beach residents reported to have received their understanding of engineered structures from studying them. Similarly, the majority of residents became aware of the natural features they were conscious of through seeing them in the area; Union Beach residents also reported that they came to learn about natural features from the government, Laurence Harbor residents became aware of natural features also from the social interactions and media. Only one Union Beach resident reported he became aware of natural systems from studying them, where a few residents in Laurence Harbor claimed to know about the natural features from studying them. The fact that more Laurence Harbor residents claimed to have studied the mitigation infrastructures may also have influenced their willingness to volunteer descriptions of those structures and features they were aware of.

The residents in the two study areas received their information about mitigation proposals from different sources. In Laurence Harbor, those that knew about proposals received information of engineering projects from a mixture of sources (news/ media, family/ friends, government and organizations) while awareness of projects to enhance natural features more commonly came from an organization or the government. Conversely, most of the residents in Union Beach heard about engineered proposals from the government and those that had knowledge of natural project proposals received their information from a variety of sources: news, neighbors/ friends or the government.

Other studies investigating local public perception of coastal risk and mitigation measures have reported that the least likely source of awareness about mitigation interventions comes from government and local institutions. Santos et al. (2013) found that Portuguese coastal residents' risk perception is based on experience and consequence to themselves or their property. Kochnower et al. (2015) found that local stakeholder perception of the benefits provided by natural infrastructure is more likely informed from heuristics and ecocentric values than objective information from other stakeholders. Myatt et al. (2003) found that the highest awareness of a managed realignment project in the Freiston Shore, Lincolnshire in the United Kingdom was correlated to residents' proximity to the site of the project and the media was most effective in informing stakeholders about the managed realignment scheme. The current sources of information and stakeholder awareness differs depending on the mitigation strategy and type of infrastructure.

6.2 Residents' Perception of Mitigation Infrastructure

The participants' volunteered descriptions of the infrastructures when shown the pictures demonstrates what they are most cognizant of. Laurence Harbor residents were most cognizant of the engineered structures role in reducing erosion, the wetland reducing flooding and being a place for water to go, and the dune area reducing impact from storms and reducing erosion. A number of Union Beach residents' volunteered descriptions of the engineered structures were that the structures do not do anything to mitigate coastal hazards: something not claimed by Laurence Harbor residents. Many Union Beach residents offered that the wetland increases flooding. Only a few Union Beach residents offered that the built structures reduce erosion or break the water and the dune area/ maritime forest is a place for water to go, dissipates storm energy, and reduces erosion.

Residents from both study areas had diverse sensibilities toward the dune/ maritime forest area, a natural, environmental feature that will attenuate wave energy and storm surge and its vegetation helps to retain sand. There was a difference in what participants offered regarding the natural area: Laurence Harbor residents offered that the natural area mitigates erosion where no one from Union Beach offered that description.

Although not all study participants volunteered descriptions of the functions of the structures and features shown, evidence of their perception of the role of the infrastructures came out with other lines of questioning whether directly to the type of hazard or indirectly when asking about benefits or problems of the subject feature or structure. Residents from the two communities differed in their perceptions of mitigation infrastructure with respect to specific coastal hazards (Figures 6.1, built structures, and 6.2, natural features). Laurence Harbor residents were in high agreement that the dune area reduces all types of coastal hazards, whereas the perceptions of Union Beach residents of the mitigation functions of the dune/ maritime forest area were more varied. There was less agreement among Union Beach residents to the storm and erosion mitigation functions of the maritime forest/ dune area then in Laurence Harbor. Participants from both study areas were clear that their understanding of the functions of natural infrastructure in mitigating low-level hazards, not extreme events.

Overall residents in both study areas did not have a difficult time thinking about the functions of the engineered structures and natural features when asked about specific hazards. Study participants were clear when discussing the storm mitigation functions of the infrastructures that the functions were dependent on the type of storm: many stating that none of the infrastructures would make a difference during extreme events like Superstorm Sandy. More residents in Union Beach than Laurence Harbor believed that the engineered structures and natural features either did not reduce erosion or where unsure about the function of the infrastructures in regards to erosion. The exception is awareness of the revetment/ bulkhead which can be attributed to the fact that erosion is not a hazard the Union Beach residents are most concerned with.

In both study areas, residents were most uncertain about the natural infrastructure's and groin's function in reducing impact from storms and the groin's function in mitigating erosion. Residents from both study areas had a good understanding of the mitigation functions of the wetland but only the residents of Laurence Harbor had an accurate understanding of the functions of the dune/ maritime forest area. It was more common for Union Beach residents to believe the dune/ maritime forest area do not mitigate coastal hazards, or be unsure of its functions, than it was in Laurence Harbor (Figure 6.2). The salience of storm-induced flooding among Union Beach residents most likely influenced those that first volunteered that the wetland increases flooding since most residents when directly asked about the wetland's function with respect to flooding related with rain events and high tide said that the wetland reduces flooding.

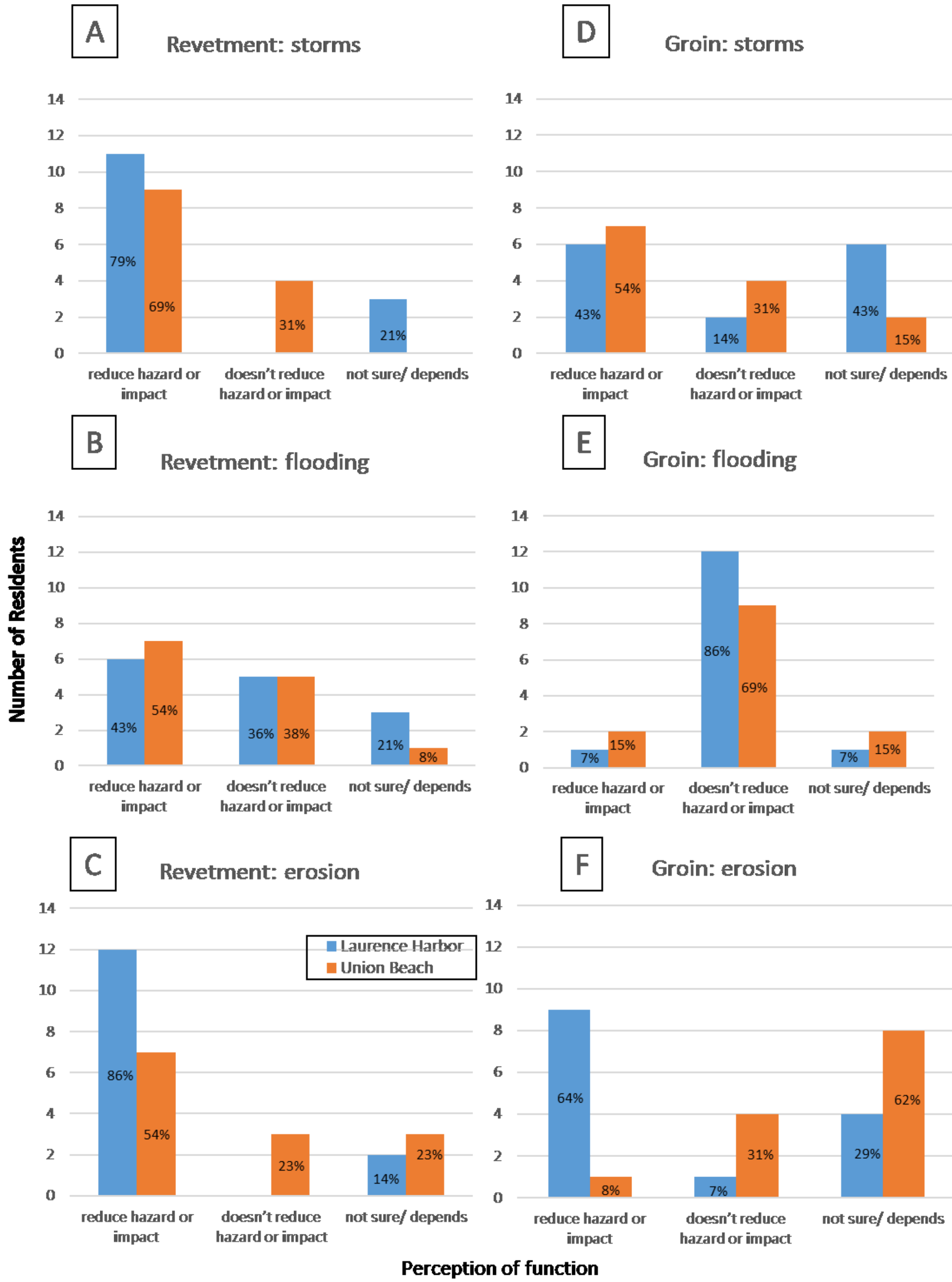

Figure 6.1 Coastal residents' perception of the functions of specific types of engineered mitigation infrastructure (revetment/ bulkhead (A-C) and groin (D-F)) associated with specific coastal hazards: storms (A and D), flooding (B and E), and erosion (C and F): number of residents and percent of study group with given responses.

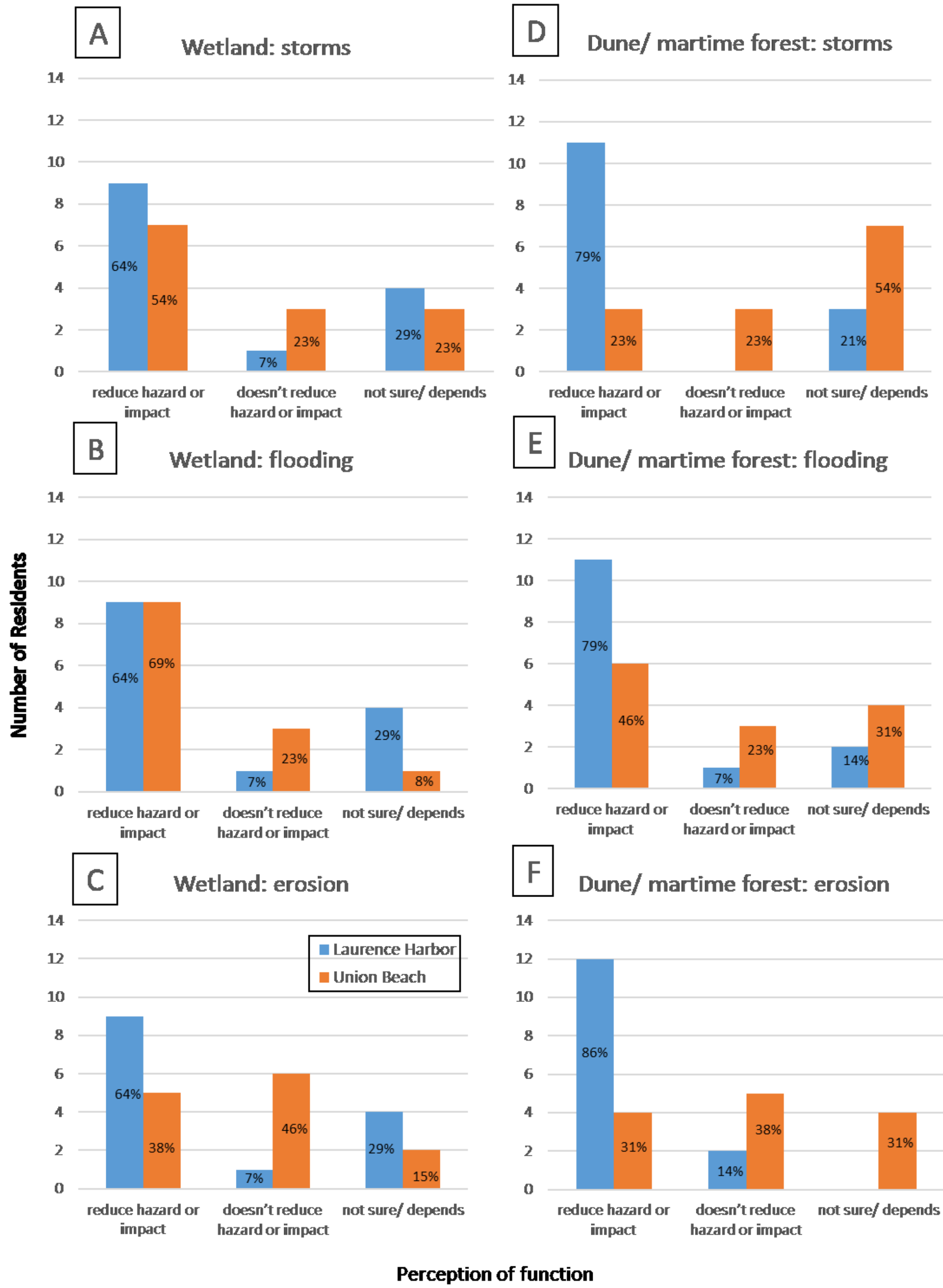

Figure 6.2 Coastal residents' perception of the functions of specific types of natural mitigation infrastructure (wetland (A-C) and dune/ maritime forest (D-F)) associated with specific coastal hazards: storms (A and D), flooding (B and E), and erosion (C and F): number of residents and percent of study group with given responses.

Sixty-three percent (63%) of all participants claimed that engineered infrastructure functions better to mitigate coastal hazards. Although the geographical characteristics of the study areas are different, Santos et al. (2013) found residents in a coastal area of Portugal almost equally divided in their perception of function of engineered infrastructure, with approximately half believing that engineered structures are effective, albeit for the short term, and the other believing them to be ineffective and producing adverse impacts elsewhere. Santos et al. did not ask residents to compare natural and engineered infrastructure, so it is unclear if their results would be similar to those presented here if that was part of their research question. In this study, although the majority of the study participants perceived engineered infrastructure to function better to reduce coastal hazards, only 33% generally preferred engineered infrastructure. This may be influenced by the perceived ancillary benefits of the infrastructures and/or a result of the consideration of the relationship between the infrastructures.

Participants began to make connections between the two types of infrastructures as the interviews proceeded, often expressing concern for the impacts of the built structures on the natural features even before being asked about the relationship between the infrastructures. Despite the few residents that mentioned having a difficult time conceptualizing a relationship between the infrastructures, responses from residents in both study areas about the relationship between mitigation infrastructures were similar: the majority believing that the infrastructures affect each other. However, residents were mixed in their understanding of how the infrastructures affect each other. Approximately half of all the study participants perceived the relationship between the infrastructures to be positive during storms, yet there was divergence between the two study groups on the relationship of the infrastructures when it comes to erosion and flooding.

Laurence Harbor residents generally perceived the relationship to be positive for all hazards where Union Beach residents only believed the infrastructures to support each other during storms (Figure 6.3). A more common perception among Union Beach residents than those in Laurence Harbor was that there is no relationship between the infrastructures with regard to flooding and erosion. Unlike Touili et al. (2014)'s findings with governance stakeholders who perceived a redistributive effect of engineered infrastructure, displacing flood waters or causing erosion elsewhere, a conflict or contradiction between the functions of the infrastructures was not a common theme in this study. In both study areas, residents were divided in their perceptions of the advantages of the infrastructures on each other. Although responses in both study areas were mixed on advantages and if the relationship between infrastructures is positive or negative, all participants said the both natural and engineered infrastructures could and should be used, not many see a conflict between utilizing both types of infrastructures.

A number of residents in both study areas discussed that engineered structures displace water to the natural features which serve as a place for water to go, thereby supporting the view that the infrastructures support each other or work together to reduce flooding or impact from storms. The stakeholders in Touili et al. (2014)'s study considered this displacement as a distribution of risk from flooding, however that was not a theme identified in this study.

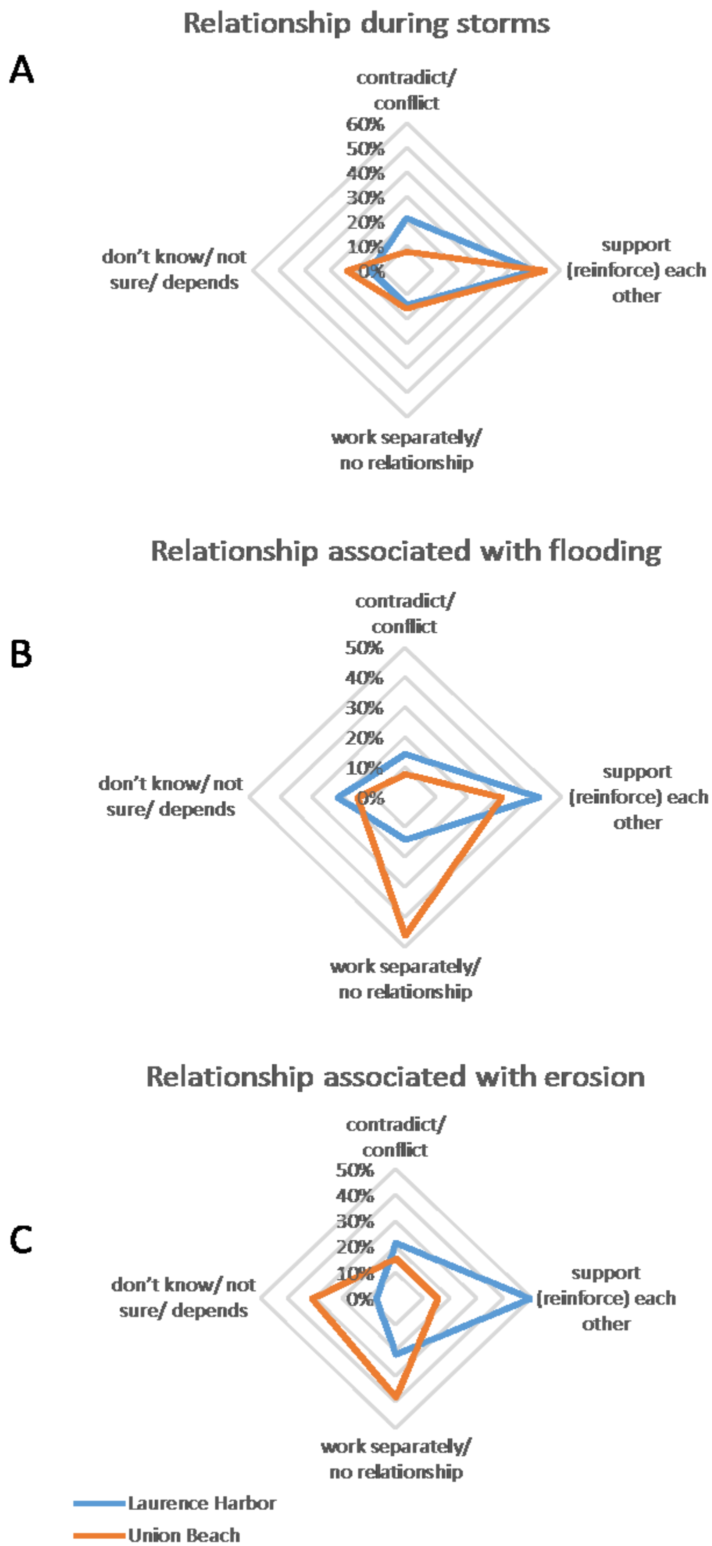

Figure 6.3 Residents' perception of the relationship between mitigation infrastructures associated with specific coastal hazards: A: Relationship during storms; B: Relationship associated with flooding; C: Relationship associated with erosion. Presents the percentage of participants from each study area who responded a certain way.

Relating public perception to scientific understanding

How residents' understanding of the functions of and relationship between mitigation infrastructure corresponds to that of scientific knowledge is relevant to governance and decision-making. There is a disagreement in the literature regarding the concurrence of public understanding of ecosystem services with that of scientific knowledge. A few studies have shown that residents in coastal areas have an appreciation of the mitigation functions of wetlands consistent with that of scientific understanding. Kim and Petrolia (2013) found that residents in coastal Louisiana associated the loss of coastal wetlands with decreases in protection from hurricanes and Curado et al. (2014) found that 41% of the coastal residents they interviewed perceived coastal marshes to provide flood control and 53% perceived these natural features to help reduce the impact from climate change, consistent with that of scientific understanding. Conversely, Lugnot and Martin (2013) found a disconnect between the knowledge of a specific stakeholder (farmers) and scientific knowledge when it comes to the ecosystem services of maintaining biodiversity not being relevant to the concerns of the stakeholders: The farmers were unable to perceive a benefit to their livelihood and this is important in justifying decisions associated with protecting biodiversity. Munji et al. (2014), in contrast to Kim and Petrolia's study, found that the public in coastal areas of Cameroon do not perceive the loss of mangroves to be a factor contributing to flood risk. Unlike a number of studies that directly investigated the perception of stakeholders to different types of ecosystem services, this research finds that coastal residents find relevance of the natural features in mitigating coastal hazards as well as other ecosystem services such as provision of habitat. Most of the participants in this study understand that natural environmental features, such as wetlands, dune and maritime forest systems, serve a hazard mitigation function. In fact, a majority of the participants in this study believe that the wetlands in their area reduce impact from storms and reduce flooding, a concurrence with scientific knowledge of the disruption prevention service afforded by coastal wetlands.

Much of existing research anecdotally suggests that the public understands the engineered functions of structures, such as dikes and seawalls, since they prefer them for hazard mitigation (Friesinger et al., 2010; Koutrakis et al., 2011; Myatt et al., 2003). Touili et al. (2014), in investigating the drivers of public perception toward engineered mitigation strategies, uncovered that the public recognize the redistributive effects of engineered strategies. These studies have not directly investigated the public's perceptions of how these engineered structures work to mitigate hazards. Only a few studies have revealed how the public perceives the functions of engineered mitigation infrastructure. Santos et al. (2013) found that the public perceive the functions of coastal hazard mitigation structures, such as groins, to enhance sand accumulation and reduce the "destructive forces of the sea," a concurrence with scientific understanding. Existing research suggests that the public in coastal areas have a better understanding of the functions of engineered infrastructure than that of natural infrastructure. This was a first study that directly investigated the public's perception of the functioning of both engineered and natural infrastructures and the relationship between them associated with coastal hazards. Although there were a number of similarities in understanding of the mitigation infrastructure, there were location-specific differences.

In this research, one study area's residents' understanding of how both types of the mitigation infrastructures work to reduce hazards or impact from hazards shows a high concurrence with the scientific understanding. The majority of the Laurence Harbor residents believe that the revetment reduces impact from storms, both the revetment and groin mitigate erosion, and both the wetland and dune area reduce all coastal hazards. This is consistent with scientific knowledge of the functions of these infrastructures. As explained in Chapter 2, revetments and groins are designed to mitigate erosion, and both wetlands and dunes reduce wave and wind energy thereby having the potential to reduce impact from storms and storm-induced erosion, reduce water surge and resulting flooding (USACE, 2013a). In Union Beach, although not as frequently as in the Laurence Harbor case, most of the residents had a good understanding of the engineered purpose of the revetment/ bulkhead but expressed very low certainty (much less than residents in Laurence Harbor) about the purpose of the groin in mitigating erosion. There was also good concurrence between Union Beach residents and scientific knowledge about the functions of the wetland in mitigating flooding and impact from storms and some similar understanding of the dune/ maritime forest in reducing the impact from flooding.

Ancillary benefits and problems of mitigation infrastructure

Many of the participants had opinions about the ancillary benefits and problems of the infrastructures except 58% of Union Beach participants who did not perceive any problems with the engineered infrastructure and 42% did not see any problems with natural infrastructure. All Laurence Harbor residents reported some concerns with the infrastructures: contamination of the engineered features and the collection of garbage around them, and the natural features being breeding grounds for flies/ mosquitos. An unusual response that was heard from a 67-year old male from Laurence Harbor and a 45-year old female from Union Beach was that built structures can create hazards and problems from either being poorly constructed or when they are damaged. They both equated this to a longer-term benefit of natural features which do not create such problems. The most commonly perceived ancillary benefit of the engineered structures was their provision of recreational opportunities. The most common benefits residents perceived of the natural features was support for wildlife, recreation and beauty. Similarly, in a study by Curado et al. (2014), residents in a coastal area of Spain perceived wetlands to provide the benefits of habitat provision and beauty while the most commonly heard problem was that wetlands are breeding ground for mosquitoes.

Although residents in both study areas perceived a lower cost, less maintenance, and longer-term benefits of natural features, engineered infrastructure was perceived to function better to mitigate coastal hazards as well as provide recreational benefits. The benefits of natural infrastructure that residents in both study areas mentioned were the provision of ecosystem services (mostly support of wildlife), recreation, and aesthetics. The reasons for preferring certain mitigation infrastructure include reducing hazards (in both study areas) and aesthetics, recreation, and natural/ ecosystem benefits (Laurence Harbor). Only two Union Beach residents mentioned the visual improvement of the area created by their preferred infrastructure and no one from Union Beach mentioned ecosystem benefits as a justification of their preference.

Differing perceptions of the benefits of mitigation infrastructures will influence the willingness to support the utilization of those infrastructures for one's community. And, officials and decision makers, when presenting and discussing options for structural strategies should bear in mind the public's perceptions of the benefits and problems of these infrastructures. Stakeholders will support interventions such as the construction of mitigation infrastructure or enhancement of natural features based on the perceived benefit afforded to them: not only the mitigation of coastal hazards, but also the provision of visual improvement to the community, recreation, and ecosystem benefits.

6.3 Residents' Preferences for Mitigation Infrastructure

This research revealed that most participants perceive a role of both natural and engineered infrastructures in reducing coastal hazards. Nearly all participants believed that both infrastructures should be used to mitigate hazards: a finding that seems to be related to the concerns of addressing coastal hazards. There was not majority or consensus among residents on what should be done or which infrastructures are preferred for mitigating coastal hazards a finding similar to that of Koutrakis et al. (2011) who investigated preferences of beach users for hard and soft strategies to mitigate coastal erosion. Koutrakis et al. found that there was not consensus among these stakeholders on preferences for mitigation strategies.

Boyer-Villemaire et al. (2014) found that low awareness of coastal mitigation strategies leads to a fragmentation among the public of preferences. This research, too, has found that where there is a low awareness of existing mitigation infrastructure and low awareness of proposed projects there is greater range of preferences. In both study areas, residents had a diversity of preferences for new or enhanced mitigation infrastructure. Interestingly, five residents in Laurence Harbor stated that there was no new mitigation infrastructure they would like to see, a response only given by one Union Beach resident.

Residents in the two study areas differed in their preference for the use of specific engineered structures and natural features. Residents in Laurence Harbor were more likely to prefer specific natural features and focus on the reduction of erosion hazards than residents in Union Beach. The strongest preference for natural infrastructure among Laurence Harbor residents was for vegetation. This is consistent with the finding that many of Laurence Harbor residents were most aware of vegetation in providing mitigation against coastal erosion. This is similar to the findings of Mustelin et al. (2010) who found that coastal communities in Zanzibar recognized the role of beach vegetation in acting as a buffer against coastal hazards and the overwhelming preference for mitigation was further beach plantings. A number of individual preferences fell outside the frequent preference for vegetation or "nothing new" in Laurence Harbor and seawall/ flood wall/ flood gate in Union Beach. Groins, dunes, beach replenishment, wetlands, bulkheads, and a comprehensive project were only mentioned by a few participants in the two communities.

In Union Beach, specific engineered structures were preferred for their perceived function of reducing flooding. More Union Beach residents preferred enhancing existing infrastructure than was expected based on the low initial awareness of these infrastructures. A few residents preferred to enhance the existing bulkhead and groin when only one person was cognizant of the groin and one of the bulkhead at the beginning of the study. Other researchers have concluded that lack of familiarity or awareness of mitigation strategies limits the ability of the public to form an opinion: the public will support strategies when they have awareness and knowledge of those strategies (Myatt et al., 2003; Roca et al., 2012). Myatt et al.'s findings suggest that the public will support and have a favorable opinion about the use of natural infrastructure if they are familiar with its functions. The finding from this study, that more residents preferred enhancing existing engineered infrastructure then were cognizant of that infrastructure at the onset of the study, suggests that participation in the interview, being asked about perception of function, raised awareness and influenced preference.

This research also reveals that preference for mitigation infrastructure is not solely related to perception of it being better for the area. Touli et al. (2014) found that personal and collective heuristics of engineering options may lead to the acceptability of options and not directly linked to the engineered infrastructure's performance in mitigation hazards. Koutrakis et al. (2011) found that stakeholder support for the use of soft measures to mitigate erosion was correlated with a perception that hard structures have a negative impact on the landscape and wildlife. There was also a greater stakeholder preference for the use of natural infrastructure in areas where natural features are already abundant and the perception of erosion as a problem is low.

Other researchers have found that the ancillary benefits of natural infrastructure such as ecological and aesthetics influence perception and preference more than mitigation functions do (Curado et al., 2014; Kochnower et al., 2015; Tunstall, 2000). Karrasch et al. (2014) found that stakeholders most often focus on the social benefit of natural infrastructure, nature's aesthetic quality in providing improvement to their surroundings and the livability of their area. Less than a third of the expert stakeholders in their study were aware of the mitigation functions of natural infrastructure and, other than those stakeholders representing nature conservation interests, most stakeholders favored engineered infrastructure. Koutrakis et al. (2011) also found that aesthetics and working better were reasons for preferring particular mitigation strategies whether engineered or natural.

This study has shown that coastal residents have some appreciation of the mitigation functions of natural infrastructure although they do not believe natural infrastructure performs better to mitigate coastal hazards. Despite this, more people responded that they prefer natural infrastructure over engineered than responded that natural infrastructure functions better: only 15% of all study participants claimed that natural infrastructure functions better than engineered infrastructure, yet 52% preferred that either natural infrastructure be used alone or in combination with engineered infrastructure for mitigating coastal hazards. Fifteen (15%) percent of all the study participants were unsure about which type of infrastructure was better for their area.

Figure 6.4 shows that there is not much difference between the study groups in the residents' perceptions of the type of infrastructure that is better for their area or in their general preferences for which type of infrastructure should be used to mitigate coastal hazards. Approximately a third of all study participants preferred engineered infrastructure and about half preferred either natural infrastructure or both engineered infrastructure and natural infrastructure together. It was surprisingly that despite the overall good understanding of the functions of both infrastructures by residents and the number of participants that perceived there to be a synergistic relationship between the mitigation infrastructure, that only two residents specified that together engineered and natural infrastructure is better for their area and only 26% residents preferred both infrastructures be used.

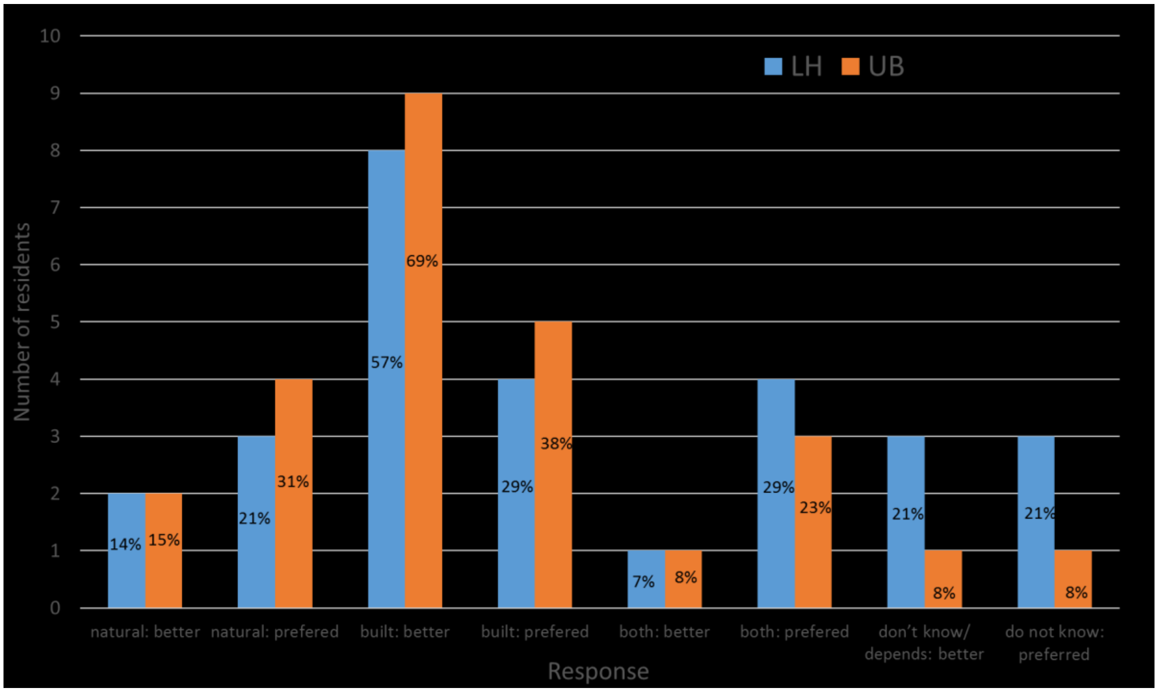

Figure 6.4 Coastal residents' perception of natural versus engineered infrastructure being better for their area and their general preference between the two types of mitigation infrastructures: built (engineered) and natural. The total number of residents (and percentage of the study group) that answered a certain way on their perception of a type of infrastructure being better and which type of infrastructure they would prefer.

The preferences for engineered versus natural and for using both were about the same in both study areas and the common justification was the preferred infrastructure "worked better". Additionally, Laurence Harbor residents were more likely to relate preference to ecological benefits, visual improvement to the area, and provision of recreational opportunity. Unique to Union Beach residents was a justification of their preferences with reference to the preferred infrastructure working in other communities (Figure 6.5). Close to half of the Laurence Harbor residents believed that their preferred infrastructures would make the community better aesthetically while capitalizing on the opportunity to remediate the existing engineered infrastructure. Unlike Laurence Harbor residents, only a few Union Beach residents mentioned long-term benefit or aesthetics when reasoning their preference. More Laurence Harbor residents than Union Beach residents associated their preference with their perceptions that the two infrastructures can work together, that using both is better and saves money in the long run, and that using both infrastructures would educate, engage, and address the needs of the public. More residents in Union Beach than Laurence Harbor mentioned trust in engineering decisions when justifying why they preferred built structures.

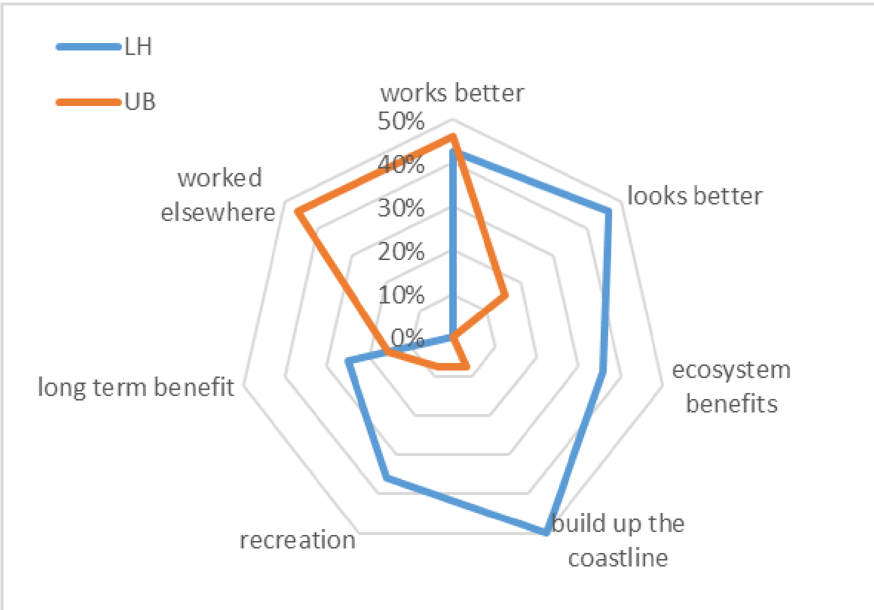

Figure 6.5 Justifications given by residents of their preference of mitigation infrastructure: percentage of each study group that answered a certain way.

Residents did not identify any conflicts between using both types of infrastructures and were not concerned with the relationship between the infrastructures when discussing their preference: no one mentioned that they did not prefer engineered infrastructure because of its negative impacts on the natural infrastructure functioning. There was a similar finding in Friesinger and Bernatchez (2010)'s study where even though study respondents were aware of the negative impact of human interventions on beaches, namely enhanced erosion, engineered structures were mostly preferred. The only case from Friesinger and Bernatchez (2010)'s study where natural infrastructure, in the form of vegetation for erosion control, was preferred was in a study area that had significant erosion resulting from rock armor interventions.

6.4 Emerging Themes

A number of additional findings emerged from what residents said that are related to the overarching themes of awareness, perception, and preference, but were not particularly expected based on the design of the interview questions. These are themes that emerged from both study groups.

The study revealed that a number of coastal area residents, despite experiencing the effects of Superstorm Sandy and more frequent impacts from coastal flooding and erosion, have not previously contemplated the function of and relationship between engineered and natural mitigation infrastructure. A resident of Laurence Harbor for thirty-seven years said that she was unfamiliar with the wetland explained that “she never paid attention to it”. She also mentioned that she has not observed the natural features working to reduce hazards or impact from hazards and was unsure if there is a relationship between the natural and engineered infrastructures because she “never really thought about it”. This lack of contemplation of mitigation infrastructure was linked to a lack of understanding about the infrastructures: some residents reported that they do not know about the infrastructures because they haven’t given thought to them. A few participants admitted that experience has made them think about the hazards faced from being in a coastal area and the importance of intervening. When asked about natural features in the area that serve to mitigate coastal hazards, a 55-year-old warehouse worker who has lived most of her life in Laurence Harbor said she had not thought about the dune area and also proclaimed that she hadn't thought about coastal hazards until Superstorm Sandy: Sandy made her realize that erosion is happening and it is a big concern for Laurence Harbor.

Residents also claimed that engineered structures and natural features exist for a reason: that there is a purpose for these infrastructures. Often this explanation was given when a participant was not able to articulate the purpose of a structure/ feature or the relationship between infrastructures. This response represents a sort of faith that there is a purpose or reason for the infrastructures' existence. This faith is tied to deference to experts. A number of residents chose to defer a personal understanding of the functions of or relationship between infrastructures to the experts' knowledge (whether engineers, scientists or decision-makers) stating that they did not know and that the experts should. Residents made judgement statements such as "engineers should know what they are doing" and "should take into account relationship between infrastructures".

Despite deference to the knowledge of the experts, some residents recognized poor governance and poor decisions: that the built structures could have been designed differently and that engineered structures result in negative consequences including interference with natural processes. Santha, et al. (2014) also found local perception of engineered interventions to have negative consequences: the majority of local stakeholders interviewed in their study claimed that engineered infrastructure has aggravated the intensity of the impact of coastal hazards. Other studies have also found that coastal stakeholders recognize the effect engineered structures have on other coastal systems and that these impacts are not accounted for in the engineering design and often attributed to a lack of coordination of decisions (Kane et al., 2014; Touili et al., 2014). This was another governance theme uncovered by this research: decisions should be better coordinated and interventions thought out and re-evaluated over time. Perception of how decisions are made and what determines what is decided influence residents' understanding of what can be done, based on what has been done (or not done). Participants also referred to their perception of coastal policies. A 37-year-old accountant from Union Beach perceived that the wetlands could not be enhanced when asked about preference and earlier in the interview stated that there is a prohibition against touching or modifying wetlands.

A few residents mentioned the importance of the existence of the mitigation infrastructures for the "peace of mind", the comfort that they provide, or impression that the area is being taken care of. Unfortunately, these perceptions can lead to a false sense of security and can obscure the perception of risk. Lopez-Marrero (2010) found that flood control projects appear to reduce the perception of risk from flooding. Interestingly, a 44-year-old city planner from Laurence Harbor claimed that the existence of both types of infrastructures has the potential to raise awareness of coastal hazard risk and mitigation thereof. Unlike the findings of Cooper and McKenna (2008) who investigated local decisions makers and the public's perception of coastal erosion mitigation practices and found that intervention into natural systems stimulates the perception that something "tangible" is being done, no one in this study mentioned the importance of maintaining or improving natural infrastructure in stimulating perceptions.

6.5 Claims Discourse

By integrating multiple disciplinary approaches and theories of risk perception, Renn (2008) summaries that perception is manifested from collective (cultural and societal) influences, reference knowledge, and personal values, beliefs, emotion, and common sense. Together these influences lead to a heuristic of information processing and are determinants for a "claims" discourse. These claims reveal what is good, tolerable, and/ or acceptable (normative claims), what matters and is deserving of attention (pertinence claims), and how things are connected/ linked (cause/ effect: evidence claims).

Touili et al. (2014) concluded that norms, pertinence, and evidence affect stakeholder's perceptions of engineered-based coastal risk mitigation strategies. Working with the same interview data and analyzing it to different extents based on their research goals, both Touili et al. and Kane et al. (2014), were able to present the perceptions of stakeholders toward engineered coastal hazard mitigation strategies in terms of the three types of claims. Kane et al., investigating how the stakeholder perceptions compared to the governance structure for making mitigation decisions, presented the normative claims as most dominant, whereby Touili et al., with a research purpose similar to the goals of this research, found that the evidence claims were most abundant in their investigation of perception of mitigation options. The research presented here, although exploring the additional mitigation strategy of utilizing natural features and specifically asking about the relationship between mitigation infrastructures, also shows public perceptions to be influenced by relevance, normative, and evidence claims. This research furthers the understanding uncovered in Touili et al.'s study by revealing what residents in two coastal towns think about the role of engineered infrastructure in mitigating coastal hazards and also what they think about the role of natural infrastructure as well as the relationship between both types of infrastructure.

What residents volunteered about the infrastructures they were cognizant of, their offered description of engineered structures and natural features shown in pictures, the influence of the most salient hazards on participants' perceptions of the infrastructures, and their perceptions of the function of the infrastructures are pertinence claims: those claims that the study participants determined were worthy of offering. The relevance claims by the stakeholders in Touli et al.'s study were associated with their perception of how the cost and extent of engineered strategies go beyond the benefits provided in terms of protection. The information volunteered by the participants in this study also included statements about how they think about the mitigation structures and features they were aware of, as well as what they think about the structures and features shown in pictures before being asked about specific hazards. The relevance of the infrastructures they were cognizant of was related to the coastal hazards most salient to them.

Evidence claims were also found throughout the two case studies: participants were able to discuss the relationship between the infrastructures and some discussed prior decisions. A number of participants were also able to discuss proposals or planned projects for mitigation infrastructures. The themes of preference are the normative claims: those structural strategies that study participants find acceptable and better for their area. The evidence and pertinence claims made by the coastal residents in this study were valuable to put the normative claims into context. The evidence and pertinence claims are most significant to the goals of the study and the implied focus on strategies to integrate natural and engineered infrastructure as a mitigation strategy. The evidence and pertinence claims reveal what is most relevant to these coastal residents and how they make connections between the two types of mitigation infrastructure.

Value statements, such as "preferring engineered infrastructure as long as it does not interfere with natural processes", were also made by study participants. Within a theme such as preference for a type of structural mitigation strategy value statements can fall into two categories of ecocentric or anthropocentric: either a value of nature for nature's sake or a belief that nature exists for human use, respectively (Prati et al., 2016). Prati et al. found that stakeholder opinions over beach nourishment fall into these two categories: stakeholders who endorsed beach nourishment tended to report that the intervention was necessary to preserve human activities, such as recreation. Those that opposed the intervention either denied erosion was a problem or viewed the intervention as unnatural. More than half of stakeholders in Prati et al.'s study had a favorable opinion of beach nourishment. Similar to the findings of Prati et al., most of the coastal residents in this study preferred some type of engineered infrastructure as a form of intervention. The implied value of certain mitigation structures or features were revealed as residents shared what they thought about the engineered structures and natural features, especially when describing the benefits and problems of the infrastructures. Since most of the interview questions focused on the coastal hazard mitigation benefits of the infrastructures, most of the value statements were anthropocentric. Most of the ecocentric value statements were about the ancillary benefits of natural infrastructure, although there were references to the engineered structures' influence on nature, such as providing habitat for wildlife or interfering with nature. Kochnower et al. (2015) found that the perceptions of stakeholders in three U.S. coastal areas toward the benefits of natural infrastructure stem from emotional connections to place and history, revealing an ecocentric view. The Laurence Harbor residents had more ecocentric statements regarding an engineered structure, the revetment, then Union Beach residents where only two residents made ecocentric value statements about the bulkhead/ revetment.

Touili et al. (2014) concluded from their study of stakeholder perceptions of engineered mitigation infrastructure that norms, relevance, and evidence influence perceptions toward engineered-based risk mitigation options. This study presents coastal residents' pertinence claims of those infrastructures that are perceived to be better or function better, evidence-based claims of what has been witnessed and the connections that residents make between the infrastructures, and normative claims of what is preferred. Value statements were made by some participants that were distinct from the normative claims such as: nature "knows what it needs" and is the "way it should be", and "everything that man touches he screws up".

An individual's perception of hazard mitigation infrastructures is influenced by collective and personal manifestations which includes experience from living in the coastal area (empirical knowledge) as well as social sources (family, friends, neighbors), formal sources (government, organizations, media) and objective information. Lack of awareness of mitigation infrastructure, either from lack of experience or familiarity with mitigation infrastructures, may lead to uncertainty about its use (Roca et al., 2012). The findings of Roca and Villares (2012) suggest that an individual's lack of understanding about the functioning of mitigation infrastructures may also influence preferences. The majority of the residents who participated in this study understood the functions of the mitigation infrastructures discussed and most of their understanding is in agreement with scientific understanding. Most were aware of mitigation infrastructure that includes natural features that serve to reduce impact from coastal hazards. This research demonstrates that the public from coastal areas do understand the functions and relationships between the engineered and natural infrastructure and that residents have a diversity of preferences for and perspectives of mitigation infrastructure.

CHAPTER 7

CONCLUSIONS

This research has revealed the similarities and differences between how people living in two coastal communities perceive the role of engineered structures and natural features in mitigating coastal hazards and the impact from them. The relevance of these two types of infrastructure is highly localized to the study area and the coastal hazards that are most salient to residents. This research has uncovered that evidence and pertinence influence resident's perception of these infrastructures. Unlike previous research, this study revealed residents' preferences for natural and engineered infrastructure along with their perceptions of their functions and relationship between the two as well as the sources of their awareness of the infrastructures.

The majority of residents in both study areas became aware of the structures and features discussed from witness or seeing them. The source of awareness of those structures and features that residents were cognizant of before being shown pictures came from more diverse sources such as studying, the government, and social sources. It was more common for those that were aware of proposals to build or enhance mitigation structures to know of the proposals from the government (Union Beach) and from social sources (Laurence Harbor). These findings indicate that government or official announcements are not currently a significant source of learning about functions of mitigation infrastructure.

The full set of interview questions was important for eliciting information to address the research questions because new understanding of residents' perception was gained as the interviews progressed. The findings indicate that many residents have thought about the subject topics more than was expected based on the lack of previous research investigating the topics. Those residents' preconception of much of the subject topics was made evident through what participants volunteered before being probed. Although those participants who volunteered description of the subject topics did not necessarily volunteer the entire set of information sought, there was more volunteered information than expected. This research indicates that residents in coastal areas without training in engineering or ecological science have the ability to understand and already have some basic understanding of the functions of engineered and natural infrastructure.

The use of photos from the study areas and the associated responses elicited during the interviews was valuable to get detailed responses on the perception of the function of individual structures and features as well as assisting in the participants' explanation of the perceived relationship of the functions of the mitigation infrastructure. There were benefits to the use of the photos in aiding the discussion on awareness, function and relationship between infrastructures. And, most residents had different terms they used for the structures and features discussed, so the use of the photos helped to ensure that residents were discussing the same structure/ feature from their area.

The findings reveal that the consideration and perceptions of mitigation infrastructures is related to the most salient coastal hazard concerns or risks for the area: for Laurence Harbor, erosion, and Union Beach, flooding from storms and high tide. The salience of erosion among Laurence Harbor residents seems to influence both the awareness of natural infrastructure and the high preference of the use of vegetation to mitigate coastal hazards. Likewise, the salience of flooding and impact of storms in Union

Beach seems to influence both the low awareness of mitigation infrastructure and the higher prevalence of preference for use of floodwall and floodgate.

This study has revealed that the lack of awareness of an engineered mitigation structure or natural feature does not limit the ability of residents to think about how it might function. Participants were able to describe what they think about structures and features even if they did not think of them when first asked about infrastructure they knew about that serve to reduce hazards or impact from hazards: the salience of existing mitigation infrastructure to study participants does not entirely determine their perceptions of the infrastructures. Other studies have indicated that awareness of existing mitigation infrastructure influences opinion, so it was expected that the public would only have an opinion about the function of mitigation infrastructure if they were aware of them. Koutrakis et al. (2011) found in coastal areas with a number of natural features, perception of coastal erosion hazards is lower and there is less support for engineered strategies. Tunstall et al. (2000) found that if the public understands the existing engineered infrastructure for flood mitigation they think less about flood risk.

Since there are limited examples of the explicit use of natural infrastructure in the two study areas for the purposes of hazard mitigation and low awareness of proposals for enhancing natural infrastructure, the study participants' perceptions of the role of natural infrastructure is limited to the personal heuristics that comes from experience with living in the area and "seeing" the natural features. Personal values and attitudes towards nature, and the natural, environmental areas shown in the pictures seem to influence a number of the participants' perceptions of natural infrastructure. Collective influences such as information received from organizations or neighbors and friends also influence the perception of natural infrastructure's role in mitigating coastal hazards.

The focus of this research study was public perception of mitigation infrastructures as they pertain to common coastal hazards. The expert understanding is that natural infrastructure provides coastal hazard mitigation benefits from more frequent, low intensity coastal hazards of erosion, everyday flooding from high tide and precipitation events and minor storms, not extreme storm events such as Superstorm Sandy (Arkema et al., 2013; Shepard et al., 2011; Spalding, McIvor, et al., 2014). These hazard mitigation benefits of natural infrastructure were recognized by study participants. Engineered structures are designed for projected hazard conditions to reduce shoreline erosion (groins), protect low-lying areas from flooding (floodgates, seawalls, levees), and curb further erosion and protect property (revetments and bulkheads) (USACE, 2013a). Coastal residents participating in this study also generally understand the functions of the engineered infrastructure discussed and recognized that these structures would reduce the impact from normal storms and high tide events. Participants were clear in their description of the functions of the mitigation infrastructure discussed that the extent of their function in mitigating coastal hazards depends on the extent of the hazard.

Given the lack of previous research directly investigating public awareness of coastal hazard mitigation infrastructure this research first sought to understand the level of awareness of mitigation infrastructure among residents in coastal areas. It was unexpected that Laurence Harbor residents would be more cognizant of existing engineered infrastructures than Union Beach residents, especially given the recent experiences of Superstorm Sandy and recent discussions over the pending USACE project. It was surprising that any Union Beach residents, let alone five residents, would be unaware of the existing engineered structures as serving to reduce coastal hazards. It was also unexpected that there would be such a difference in awareness of natural infrastructure between the two study areas since natural areas are so similar.

The current discussions over the remediation of the engineered structures in Laurence Harbor influenced the heightened awareness. The objective exposure to risk from flooding and the widespread damage from Superstorm Sandy seems to have influenced the lower awareness of Union Beach residents towards any built structures or natural features in the area that serve to reduce impact from the coastal hazards they are most concerned about. Experience influences participants' perception of the functions of the existing infrastructure. The disaster experience of Superstorm Sandy in 2012 seemed to influence the perception of Union Beach residents that the existing infrastructure was either not good enough or does not serve to mitigate coastal hazards. These infrastructures were also less salient to Union Beach residents.

The majority of residents became aware of the structures and features they mentioned and those they were shown pictures of from seeing the structures and features. Exceptions include a number of Laurence Harbor residents who said that they became aware of the natural features they mentioned from more formal sources of learning and inquiry and a few residents in Union Beach whose source of awareness of the structures or features they mentioned coming from social interactions or government officials. This research finds that, for the most part, the perception of mitigation infrastructure has formed from informal and personal heuristic, not from formal definitions or formal sources.

Prati et al. (2016) concluded that conflict over coastal mitigation strategies is due to mixed perceptions of the problem as well as diverse perceptions of the efficacy of the proposed solutions. This study has found that the salience of coastal hazards influence preferences as well as the perceptions of how existing infrastructures work with regards to those coastal hazards that residents are most aware of.

7.1 Significance of the Study

This is the first research study that presents public perceptions of both the role of and relationship between natural and engineered infrastructure with the perspectives of preference for the use of these infrastructures. Other research has presented public perceptions of engineered infrastructure or of ecosystem services, including the role of natural infrastructure in coastal hazard mitigation. None have integrated those perceptions to the holistic nature of coastal mitigation infrastructure to include both engineered and natural infrastructure.

The responses provided by the participants in this study has revealed a local understanding that is not always presented in public forums, such as public hearings on proposed projects. This perspective sharing is important for coastal mitigation policy. For more integrated policies to be pursued there must be a public demand (Prater et al., 2000). For the public to demand the integration of natural and engineered infrastructure, they must understand and appreciate the role of both types of infrastructures in mitigating coastal hazards as well as their benefits, including ancillary ones, such as water quality improvement and habitat provision from natural infrastructure and enhancement of recreational opportunities that can come from both types of infrastructure (Cooper et al., 2008; Karrasch et al., 2014). This understanding must include the relationship between infrastructures in mitigating coastal hazards: how they can work together and what the limitations of utilizing both may be.

This study concludes that although all participants believed that both infrastructures can and should be used they expressed a range of opinion and perspective about them, including their specific preferences. Since this study has found that residents in coastal areas have a basic understanding of the functions of both engineered and natural infrastructure, but less understanding of the relationship between them, public sensibility towards utilizing both types of infrastructures in a more comprehensive fashion may be enhanced with targeted discussion about integration of the two. Boyer-Villemaire et al. (2014) found that targeted education on coastal phenomena and available solutions results in positive responses to mitigation interventions and, when there is a lack of information about interventions, hard structures are commonly preferred. The research of Myatt et al. (2003) suggest that the public must have an awareness of intervention strategies in order to form an opinion. This was reinforced by a statement from an 85-year old Union Beach resident interviewed for this research who said he did not know what he preferred, that he "would have to see the options". Karrasch et al. (2014) found that upon explaining to stakeholders the mitigation functions of natural infrastructure and ecosystems' potential as an alternative to engineered strategies, the participants' awareness increased and those participants were able to identify the relevance of ecosystems in providing services such as disruption prevention. The fact that the clear majority of participants in this study were able to think about the functions of the infrastructures indicates that interventions such as awareness-raising campaigns, education and outreach on the options available may prove beneficial for more local support of integrative mitigation strategies. Additionally, the public will be more engaged in discussions about coastal mitigation options if they feel informed and knowledgeable about mitigation options (Godschalk et al., 2003). This research indicates that residents in coastal areas can think about the functions of both engineered and natural infrastructure and that the public may be receptive to comprehensive and integrated mitigation strategies that utilize both engineered and natural infrastructure, especially if they are further informed about the functions of both and relationship between them.

7.1.1 Impact of the Study on Participants

A few residents concluded the interview by stating that participating in the study had given them things to think about. Going through the interview process and discussing the functions of the existing infrastructures in itself raised awareness. The participation in the interview process may have enhanced the ability of the residents to think about the existing infrastructures' function. Even though many were unable to describe existing features or structures at the beginning of the interview, it is possible that going through the interview and being prompted to think about the functions of the structures and features shown in the pictures increased interest in seeing them improved upon. By being a part of the study, the participants were challenged to think about the existing infrastructures, especially the role of natural infrastructure, in a way they have not before.

It is expected that those that participated in the study are now more aware of the existing engineered structures and think about the existing natural infrastructure in a way they might not have before they study. It is hoped that by being a part of a discussion on integrating natural and engineered infrastructure, these residents not only will be more attune to mitigation decisions and seek out opportunities to understand options presented to them and questions those that are not. It is also hoped that these residents will consider the functions and relationship between the infrastructures when participating in coastal hazard mitigation discussions.

7.2 Limitations/ Assumptions

It is recognized that there are multiple, nonexclusive strategies to mitigating risk from coastal hazards. Although recognized as important in the overall risk mitigation governance in coastal areas, it was not the purpose of this research to evaluate public perceptions of other coastal management policies, such as flood proofing, insurance schemes, or retreat from high hazard areas.

There was some signaling to those participants with a low awareness of existing infrastructure that the structures and features shown in the pictures may have a function in mitigating coastal hazards as a result of the line of interview questions. Even if a person was not conscious of a particular structure or feature they were able to show how they reason/ can think about the functions of the infrastructures. This research indicates that much of this reasoning comes from experience or witness.

The themes uncovered by the research are specific to the perceptions and awareness of those participating in the study and are thus unique to the study areas. The results of this research cannot be generalizable or presented as representing the public at large. It was the purpose of this research to investigate only the residents in a coastal region. They are only one subset of the public at large involved in governance decisions. The research does not present broad public opinion or a collective perception by coastal residents. Since the study scale is small, the themes that arise from the research presents a purposeful sample of residents in two coastal areas.

One limitation of the findings from the Laurence Harbor case study is the contamination of the existing engineered structures, both the groin and revetment. The public concern over the contamination and focus on the options for remediation, although assisting in raising awareness of the structures, has the ability to distract the residents in contemplating the structures for the purposes of coastal hazard mitigation. Laurence Harbor residents were more focused on remediating the contamination then discussing improvements to the engineered infrastructure for purposes of reducing flooding, erosion or impact from storms. A few residents admitted that remediating the structures would not provide coastal hazard mitigation improvement. The fact that more Laurence Harbor residents than Union Beach residents were interested in pursuing natural infrastructure for purposes of coastal hazard mitigation then residents of Union Beach may be influenced by their negative perception of engineered infrastructure due to the existing contamination concerns.

The findings of this research indicates what is salient and understood by coastal area residents about both types of mitigation infrastructure and what they would prefer. This research also inquired about residents' perceptions of which type of infrastructure functions better in mitigating coastal hazards. Participants were not asked to rank the individual structures or features' function relative to each other when asked about specific hazards which may have revealed different conclusions or enhanced the findings.

Additionally, the process of participating in an interview, going through questions on the same topic, raises sensibility to the subject: in the case of this research, the function of two types of infrastructure in mitigating coastal hazards. Since the findings were analyzed through content analyses and presented by theme, it is not possible to decipher between whether what was said later in the interview process was a result of enhancing thinking on the topics from what was pre-conceived. Only the responses to the first series of interview questions (about awareness of existing built or natural features in the area that serve to reduce coastal hazards) can be considered pre-conceived understanding of mitigation infrastructure. Once the interviews proceeded and after the participants were first shown a picture of an engineered structure and asked what they thought of its role in mitigating specific coastal hazards, the response given to the interview questions must be assumed to be influenced from thinking about the topic through the answers to previous questions.

Participants were not selected for this study based on their involvement or interest in the subject of the study. Participants were not asked how involved they have been or plan to be in discussions over mitigation options for their area. Therefore, it cannot be concluded how much the participants' awareness and perceptions will affect their participation in governance discussions, if their opinions will be heard in public forums.

The information gained from this study is valuable to understand the lay public's understanding and to determine if connections are made between natural and engineered infrastructure. Although residents were able to make connections between the infrastructures functioning and describe the benefits of natural infrastructure, this research did not investigate if these perspectives will be raised during discussion of options. The findings do not evidence what people will actually do or support when given options.

7.3 Recommendations for Further Research

Since this was a small study, the themes that were identified may be useful in a more expansive study with more coastal residents as well as other key stakeholders such as local government officials, business owners, and advocacy groups. The two case studies should be expanded to include others in the local governance process that have vested interest in the mitigation decisions. The research findings will be complemented by including the awareness, perceptions, and preferences of local officials. They are essential actors in bridging the dialogue among experts, government actors, and their community members.

This research indicates that the experience of living in a coastal area, with coastal hazards and recent extreme storm events, influences perceptions. It is impossible to know if public perceptions and preferences are unique to local understanding based on experience and interest without comparing the results to that of other stakeholders. Future research should conduct the same study with the public living outside of the coastal region to determine how the range of perceptions, understanding, and preferences compare to that of residents. A larger study may reveal differences in how individuals receive their information and how influential the experience of living in a coastal area is to perception and preference. By expanding the study, we will gain more understanding of how differing interests and perspectives may influence preference for mitigation infrastructure.

The findings raise number of questions that should be further investigated. A few residents were aware of the history of decisions about the structures discussed. A future study could investigate whether there is a correlation between knowledge of the history of decisions about the infrastructures and perceptions of the infrastructures' function. Other correlations that could be investigated are whether diversity of preferences and perceptions is related to the extent of public engagement over the infrastructures, conflict over, or lack of knowledge of the options available.

This research did not explore if there are distinct typologies of perceptions of the ancillary benefits of the infrastructures or if the perceptions of these infrastructures have changed over time or what might influence a change in sensibility about the infrastructures. Further research could investigate whether there are correlations between the perceived benefits of two types of infrastructures raised by residents. A question that might be asked in future research is whether residents perceive that the two types of infrastructure will make the area better by improving recreation or improving the visual aesthetic of the area. Another study could investigate if the perceptions of mitigation infrastructure changes with time.

This study's findings also raise the question of whether awareness and understanding of mitigation infrastructures is higher for more prevalent engineered structures or natural, environmental areas. Flood gates and pumps are newer installations (proposed for Union Beach and existing in neighboring areas), the older engineered infrastructure in Laurence Harbor and Union Beach (groins and revetments) are still utilized. A number of residents in Union Beach were aware of those more recent flood mitigation strategies suggesting that as new installations go in the awareness of these structures may be higher than those installed decades ago (bulkhead). Similarly, if enhancements to or restoration of natural features is done, the awareness of natural infrastructure may be raised. Future research in these study areas could investigate if there is more awareness of and understanding of infrastructures as a result of more recent constructions or projects. It would be interesting to repeat this study in Union Beach after the USACE project is complete. Just as it was confirmed that the experience of Superstorm Sandy influenced the perspectives of residents towards coastal hazards and mitigation, the salience of mitigation infrastructure may be enhanced once the residents of Union Beach witness new installations of engineered infrastructure and have experience with their operation.

7.4 Policy Implications

All government funded projects require stakeholder engagement and public outreach. Much of this government outreach, as well as that of NGOs and advocacy groups, merely present findings and conclusions welcoming input in the form of public comment. The decisions are ultimately made by elected officials. The messages and agendas of various actors within coastal hazard mitigation governance are dependent of the knowledge base, discourse, and mission of those involved in the discussions. Therefore, the public receives mixed messages on coastal hazards and mitigation options thereof. Engineers present the available feasibility and cost-benefit analyses of engineered infrastructure to providing protection from coastal hazards. Ecological scientists focus on the multitude of benefits to ecosystem restoration. Coastal scientists discuss the hazards, changing geomorphology and effects of interventions. It is the role of policy makers to present options for coastal hazard mitigation. The diversity of actors involved in the governance process and their perspective often results in alternate, sometimes disjointed strategies (Janssen et al., 2014).

The perceptions of the public in coastal regions will help bridge the gap in discourse, especially when other governance actors understand what the public awareness and perceptions of those options are. Renn et al. (2011), through extensive literature survey, found that experts and decision-makers may misunderstand public perceptions associated mitigation options. Loomis and Paterson (2014) concluded that policy researchers and decision-makers do not understand the public's attitudes and preferences when it comes to ecosystem services in coastal areas especially how the public understands the role of natural infrastructure in providing more than just recreational and habitat services. And, this lack of understanding limits how to best produce effective coastal decisions.

To overcome the limitations of low citizen interest, conflicting priorities, lack of trust of the governance process, and diverse discourse among actors, the perceptions of all stakeholders should be understood. When presenting options to the public, scientists and decision-makers need to craft messages and talk with the public with an appreciation for what the public knows and cares about. Better communication in the governance process may be ensured by a shared understanding: both the scientific and engineering knowledge of mitigation strategies as well as the public perceptions. The findings of this study begin to address this need by presenting what residents in two coastal communities with differing sensibilities to coastal hazards think about structural mitigation options, including reliance on natural infrastructure. Only once policy and decision makers understand what the public perceptions and awareness of mitigation infrastructure are can they have meaningful and fruitful discussions with the public about options.

This research presents the perspectives and preferences of the public living in areas at risk from coastal hazards and where discussions about strategies for mitigating this risk continue. The findings of this research is useful information for decision-makers to frame the presentations of options and for proponents of integrated policies to use to gain support.

Ultimately, tax payers will pay for mitigation infrastructure and support projects based on their opinion.

In addition to improving decision-makers and scientists' understanding of public perceptions of mitigation infrastructure, this research indicates that there is an opportunity to enhance the knowledge and influence the perspective of public through more formal sources such as the government or organizations. The majority of residents that participated in this study became aware of the discussed infrastructures from experience and much less from formal sources. More formal sources of information about the functions of the two types of mitigation infrastructure could enhance the public heuristic, adding to that of experience or what is heard from other sources.

In both study areas, there was a diversity of preferences and no majority opinion on what engineered structures or natural features should be used to mitigate hazards despite the functions of both types of infrastructures being understood by most participants. This suggests that the available structural mitigation options have not been clearly communicated, if at all, to residents. The diversity of local public preferences exposed from this study suggest that policy makers may have a difficult time getting support if only one mitigation option is presented to the public. Policy makers should avail a multitude of structural mitigation options. The findings of this study suggest that policy makers have an opportunity to promote the integration of both natural and engineered infrastructures.

The relevance of mitigation strategies differed between study areas. The findings from this research make evident that decision-makers must appreciate the local publics' concerns and provide information relevant to the community they are working with. The research demonstrates that awareness and perceptions of mitigation infrastructures is highly localized. Public officials and experts must appreciate the differences in sensibility based on experience and the issues most prominent to the local public. There is an opportunity within the governance process to provide information to enhance public knowledge of the mitigation functions of both engineered and natural infrastructure. There is also opportunity to capitalize on other policy discussions such as improving the area for public enjoyment or recreational opportunity. For example, in Laurence Harbor, there is an opportunity to use the current discussions on addressing the contamination of the existing engineered structures to discuss improvements for the purposes of mitigating erosion and flooding and reducing impact from storms in addition to making improvements to the public use of the area.

The fact that a number of residents mentioned that they didn't think about the topic before participation in the study, that the study gave them something to think about, or mentioned that a question was "good" or "interesting" suggests that awareness-raising may be the best mechanism to improve dialogue on future proposals or decisions about existing mitigation infrastructure.

This research demonstrates that the perceptions of mitigation infrastructure working better mostly influences preference. The most significant finding from this research is that residents are able to understand the functions of both mitigation infrastructures and can conceptualize their effects on one another. This indicates that the public may be supportive of proposals to incorporate more natural infrastructure into a comprehensive hazard mitigation strategy if presented with such proposals. This research has found that the public understands that natural features last longer and may improve in mitigation functions over time, concepts that should be used to justify the integration of natural infrastructure into comprehensive designs. Residents in both study areas were able to identify ancillary benefits of both type of infrastructure and those benefits should also be exploited. When promoting integrative strategies, decision-makers should also focus on the regional benefits of the infrastructures supporting each other's functions.

A few participants perceived the presence of the mitigation infrastructures to be able to raise awareness and be able to serve as a teaching tool. Since this research finds that residents in coastal areas can understand the functions of natural infrastructure and can think about the relationship between natural and engineered infrastructure the study findings suggest that education on the benefits of integrating the two infrastructures into a comprehensive coastal hazard mitigation strategy may prove to garner support.

APPENDIX A

INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

IRB approval was granted to use human subjects as part of the study on May 8, 2015.

NJIT
New Jersey's Science & Technology University

Institutional Review Board: HHS FWA 00003246
Notice of Approval
IRB Protocol Number: F234-15

Principal Investigators: Jaime D. Ewalt Gray, PhD Candidate (CEE)
Advisor: Zeyuan Qiu, PhD (CEE)

Title: Public Perceptions of the Functions of Natural and Engineered Infrastructure in Coastal Risk Mitigation: The Cases of Two Communities in the Raritan Bayshore, New Jersey

Type of Review: FULL [X] EXPEDITED [ ]

Type of Approval: NEW [X] RENEWAL [ ] REVISION [ ]

Approval Date: May 8, 2015 Expiration Date: May 8, 2016

1. **ADVERSE EVENTS:** Any adverse event(s) or unexpected event(s) that occur in conjunction with this study must be reported to the IRB Office immediately (973) 596-6053.

2. **RENEWAL:** Approval is valid until the expiration date on the protocol. You are required to apply to the IRB for a renewal prior to your expiration date for as long as the study is active. It is your responsibility to ensure that you submit the renewal in a timely manner. Minor changes – data collection session will be repeated at 3-4 months intervals over a course of two years

3. **CONSENT:** All subjects must receive a copy of the consent form as submitted. Copies of signed consent forms must be kept on file with the principal investigator.

4. **SUBJECTS:** Number of subjects approved: 24-30

5. The investigator(s) did not participate in the review, discussion, or vote of this protocol.

6. **APPROVAL IS GRANTED ON THE CONDITION THAT ANY DEVIATION FROM THE PROTOCOL WILL BE SUBMITTED, IN WRITING, TO THE IRB FOR SEPARATE REVIEW AND APPROVAL.**

Norma Rubio, IRB Co -Chair,

APPENDIX B

PARTICIPATION CONSENT FORM

As part of the agreement to use human subjects as part of the research, participants were required to consent to be interviewed.

NEW JERSEY INSTITUTE OF TECHNOLOGY
323 MARTIN LUTHER KING BLVD.
NEWARK, NJ 07102

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

TITLE OF STUDY:
Public Perceptions of the Functions of Natural and Engineered Infrastructure in Coastal Risk Mitigation: The Cases of Two Communities in the Raritan Bayshore, New Jersey

RESEARCH STUDY:
I, ____, have been asked to participate in a research study under the direction of Jaime Gray & Dr. Zeyuan Qiu. Other professional persons who work with them as study staff may assist to act for them.

PURPOSE:

The purpose of this study is to understand what residents from two communities in the Raritan Bayshore, New Jersey understand and think about the physical features in the area that exist to reduce damage or impact to the area from coastal hazards such as storm events and their associated surge, waves, and precipitation, coastal erosion, and flooding. The goal of the research is to inform decisions concerning structural mitigation strategies and enhance risk mitigation governance.

DURATION:
Individual participation in this research will last approximately one (1) hour.

PROCEDURES:
It has been explained that, during the course of this study, the following will occur:

Research participation is being solicited through community organizations and the researcher's contacts in the region. Participants should have lived in the area for at least five (5) years and must be able to speak English clearly. One interview will be conducted unless the participant withdraws or is otherwise terminated from the study. Interviews will be conducted by the principal investigator, Jaime Gray, in a mutually agreed upon location by the researcher and the participant.

The voluntary nature of the participation in the research will be explained including the interview process. A willing participant must sign this consent form to participate in the interview.

All interviews will be voice recorded[1], used as data, and analyzed. Preformed questions will be used to guide the interview. A number of questions will refer to photographs of physical (human-built and natural) features from the area.

The individual name of the participant will not be revealed in any publications of the results.

PARTICIPANTS:
There will be 24-30 participants in this research. The information provided by the participants will be used for a dissertation.

EXCLUSION
Participants will inform the researcher if they do not speak English.

[1] The interview will cease and recording will be stopped and destroyed if the participant discusses any crimes or illegal activity that is irrelevant to the study.

NJIT New Jersey Institute of Technology Approved NJIT IRB F234-15 5/8/2015

SIGNATURE OF PARTICIPANT

I have read this entire form, or it has been read to me, and I understand it completely. All of my questions regarding this form or this study have been answered to my complete satisfaction. I agree to participate in this research study.

Participant Name ______________________________

Signature ______________________________

Date ______________________________

SIGNATURE OF INVESTIGATOR OR RESPONSIBLE INDIVIDUAL (Only required for consent forms of projects requiring full IRB approval)

To the best of my knowledge, the participant, has ______________________________ understood the entire content of the above consent form, and comprehends the study. The participant's questions have been accurately answered to their complete satisfaction.

Investigator's Name ______________________________

Signature ______________________________

Date ______________________________

APPENDIX C

INTERVIEW SCHEDULE AND CODING SHEET

The schedule of interview questions is shown within the first column of the coding sheet (Table C.1). The coding sheet was used for each of the interviews. The common codes are demarked. A separate coding sheet was used for each participant.

The following narrative was used to introduce the study:

> "The purpose of this study is to understand what residents in coastal areas [such as Laurence Harbor/ Union Beach] understand and think about the physical features in the area that exist to reduce coastal hazards or impact to the area from coastal hazards such as storm events and their associated surge, waves, and precipitation, coastal erosion, and flooding. The goal of the research is to inform decisions and policy concerning structural mitigation of coastal hazards. I will ask you general questions and have you react to some photos [from the area]."

Table C.1 Interview Coding Sheet (Continued)

	Data						
Question	***potential codes or themes***						**Narrative Response**
Demographic							
I would like to start with a few background questions.							
Would tell me how old are you?							
How long have you lived in [Laurence Harbor/ Union Beach]?							
Where did you live before that time? For how long?							
Have you lived elsewhere in the area [Laurence Harbor/ Union Beach] or surrounding towns?							
Why do you live in [Laurence Harbor/ Union Beach]?	water	convenience	family	community	job	beach	house
Do you plan to stay?	yes	no					
What part of town do you live? Here is a map of [Laurence Harbor/ Union Beach]: Would you identify the part of town you live in on the map?							
What is your occupation?							
What is your educational background: highest level of education, did you study something in particular?							

Table C.1 (Continued) Interview Coding Sheet

	Data								
Question	***potential codes or themes***								**Narrative Response**
My next series of question are about physical features in the area of [Laurence Harbor/ Union Beach] that serve to reduce coastal hazards or impact from coastal hazards such as storms, associated surge, wind and wave energy, flooding or erosion. I would like to know what you know about and think of these features as they relate to reducing impact or damage to the area from these types of coastal hazards. I am looking for brief answers to these questions.									
Do you know about any human-built projects or structures along or near the coast that (are designed/ serve to) reduce coastal hazards or impact from coastal hazards to [Laurence Harbor/ Union Beach]?	know	don't know							
(If yes) Please describe one human-built coastal project or structure.	dune	groin	barrier	seawall	beach replenishment	levee	berm		
How did you become aware of it?	news	neighbor	government	see it	don't know	studied			

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Can you describe another project or structure built by humans near or along the coast that (are designed/ serve to) reduce coastal hazards or impact from coastal hazards?	dune	groin	barrier	seawall	beach replenishment	levee	berm	
How did you become aware of it?	news	neighbor	government	see it	don't know	studied	organizatio n	
[REPEAT]								
Do you know about any natural environmental feature along or near the coast that reduce coastal hazards or impact from coastal hazards in [Laurence Harbor/ Union Beach]?	know	don't know						
(If yes) Please describe one natural environmental feature.	dune	wetland/ marsh	forest	mussel beds/ break water				
How did you become aware of it?	news	neighbor	government	see it	don't know	studied		
Can you describe another natural environmental feature that you think reduce coastal hazards or damage from coastal hazards?	dune	wetland/ marsh	forest	mussel beds/ break water				

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
How did you become aware of it?	news	neighbor	government	see it	don't know	studied	organizatio n	
[REPEAT]								

(The following questions are accompanied by photos of engineered structures and natural features from the area: revetment/ bulkhead, groins, maritime forest/ dunes, and wetlands. Each picture is shown separately at first and introduced as a type of built structure or natural feature.)

Now I am going to show you a few pictures of features in the area and ask you questions about them. I am asking because I would like to know your opinion. *(Pictures shown individually and the following questions asked):*

(Shown picture of **revetment/ bulkhead**) Is this something you are familiar with? What can you tell me about this [built structure/ natural feature]? [PROBE: associated with coastal hazards]	doesn't do anything	builds up/ removes sand	prevents/ causes erosion	reduces/ increases storm damage	prevents/ causes flooding	breaks up waves	don't know	

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
How did you become aware of this [built structure/ natural feature]?	news	neighbor	government	see it	don't know	studied	organization	
Do you think this [built structure/ natural feature] reduces hazards or impact from coastal storms in [LH/UB]? [PROBE: wind/ wave energy, precipitation, storm surge]	no: doesn't reduce	yes: reduce	doesn't make a difference	not sure	depends			
Do you think this [built structure/ natural feature] reduces coastal flooding or impact from coastal flooding in [LH/UB]?	no: doesn't reduce	yes: reduce	doesn't make a difference	not sure	depends			
Do you think this [built structure/ natural feature] reduces coastal erosion in [LH/UB]?	no: doesn't reduce	yes: reduce	doesn't make a difference	not sure	depends			
Do you think this [built structure/ natural feature] has benefits not related to these hazards?	no	fishing	aesthetics	recreation	habitat	don't know	nature	

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Do you think this [built structure/ natural feature] creates any problems?	no	aesthetics	blocked access/ view	limited recreation	conflict with nature	don’t know		
(Shown picture of **groin**) Is this something you are familiar with? What can you tell me (know) about this [built structure/ natural feature]?	doesn't do anything	builds up/ removes sand	prevents/ causes erosion	reduces/ increases storm damage	prevents/ causes flooding	breaks up waves	don’t know	
How did you become aware about this [built structure/ natural feature]?	news	neighbor	government	see it	don't know	studied	organization	
Do you think this [built structure/ natural feature] reduces hazards or impact from coastal storms in [LH/UB]?	no: doesn’t reduce	yes: reduce	doesn’t make a difference	not sure	depends			
Do you think this [built structure/ natural feature] reduces coastal flooding or impact from coastal flooding?	no: doesn’t reduce	yes: reduce	doesn’t make a difference	not sure	depends			
Do you think this [built structure/ natural feature] reduces coastal erosion?	no: doesn’t reduce	yes: reduce	doesn’t make a difference	not sure	depends			

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	*potential codes or themes*							**Narrative Response**
Do you think this [built structure/ natural feature] has benefits not related to these hazards?	no	fishing	aesthetics	recreation	habitat	don't know		
Do you think this [built structure/ natural feature] creates any problems?	no	aesthetics	blocked access/ view	limited recreation	conflict with nature	don't know		
(Shown picture of **dune/ maritime forest**) Is this something you are familiar with? What can you tell me about this natural feature?	doesn't do anything	builds up/ removes sand	prevents/ causes erosion	reduces/ increases storm damage	prevents/ causes flooding	nature	don't know	
How did you become aware of this [built structure/ natural feature]?	news	neighbor	government	see it	don't know	studied		
Do you think this [built structure/ natural feature] reduces hazards or impact from coastal storms?	no: doesn't reduce	yes: reduce	doesn't make a difference	not sure	depends			
Do you think this [built structure/ natural feature] reduces coastal flooding or impact from coastal flooding?	no: doesn't reduce	yes: reduce	doesn't make a difference	not sure	depends			

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Do you think this [built structure/ natural feature] reduces coastal erosion?	no: doesn’t reduce	yes: reduce	doesn’t make a difference	not sure	depends			
Do you think this [built structure/ natural feature] has benefits not related to these hazards?	no	fishing	aesthetics	recreation	habitat	don’t know		
Do you think this [built structure/ natural feature] creates any problems?	no	aesthetics	blocked access/ view	limited recreation	flies/ mosquitos	don’t know	fire hazard	
(Shown picture of **wetland**) Is this something you are familiar with? What can you tell me about this natural environmental feature?	doesn't do anythin g	builds up/ removes sand	prevents/ causes erosion	reduces/ increases storm damage	prevents/ causes flooding	nature	don’t know	
How did you become aware of this [built structure/ natural feature]?	news	neighbor	governme nt	see it	don't know	studied	organization	
Do you think this [built structure/ natural feature] reduces hazards or impact from coastal storms?	no: doesn’t reduce	yes: reduce	doesn’t make a difference	not sure	depends			
Do you think this [built structure/ natural feature] reduces coastal flooding or impact from coastal flooding?	no: doesn’t reduce	yes: reduce	doesn’t make a difference	not sure	depends			

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Do you think this [built structure/ natural feature] reduces coastal erosion?	no: doesn't reduce	yes: reduce	doesn't make a differenc e	not sure	depends			
Do you think this [built structure/ natural feature] has benefits not related to these hazards?	no	fishing	aesthetics	recreation	habitat	don't know		
Do you think this [built structure/ natural feature] creates any problems?	no	aesthetics	blocked access/ view	limited recreation	flies/ mosquitos	don't know	fire hazard	
Now I am going to refer to the pictures as two groups of physical features: built structures and natural features. *(Pictures are laid out together into the two groups of mitigation infrastructure and the following questions asked):*								
If these two types of features are located near each other, do you think they affect each other? [Probe: Do they function differently if they are located near each other?	yes	no						
[If so] How do you think they affect each other? [Probe] Do you think that these features work together (enhance each other), work against (contradict) each other, or work separately (independently)?	negate	contradic t/ conflict	enhance	support each other	separately	not sure		

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
How do you think they affect each other during a storm?	negate	contradict / conflict	enhance	support each other	separately	not sure		
How do you think they affect each other when there is flooding?	negate	contradict / conflict	enhance	work	separately	not sure		
How do you think they affect each other related to erosion?	negate	contradict / conflict	enhance	work	separately	not sure		
Do you think there is an advantage (or disadvantage) to the built structures by enhancing natural environmental features? [PROBE: If there were more of these natural features, do you think there is a benefit (or detriment) to these built structures?]	yes	no	depends					
Do you think there is an advantage (or disadvantage) to the natural environmental features by enhancing built structures? [PROBE: If there were more of these built structures features, do you think there is a benefit (or detriment) to these natural features?]	yes	no	depends					

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Do you think that between natural features and built structures one is better than the other for [Laurence Harbor/ Union Beach]?	natural features	built structures	both					
Do you think one is better at reducing impact from coastal hazards?	natural features	built structures						
How?	more predictab le	causes more problems	breaks water/ surge	natural processes				
Do you think one is less costly?	natural features	built structures	don't know					
Why?	materials	maintenance	labor					
Do you think one has more long-term benefits?	natural features	built structures						
What are they?	gets better with time	protect area	lasts longer	self-maintaining	adapt s	habitat	recreation	
Do you think one is easier to maintain?	natural features	built structures	don't know					
Please explain.	no maintena nce	self-maintaining	know what to do					

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Do you think that both natural environmental features and human-built structures could be used in [Laurence Harbor/ Union Beach] to reduce coastal hazards or impact from coastal hazards?	yes	no	don’t know	conflict				
Do you think that both natural environmental features and human-built structures should be used in [Laurence Harbor/ Union Beach] to reduce hazards or impact from hazards?	yes	no	don’t know	conflict	built preferred	natural preferred		
Do you know about any proposals/ planned projects to build coastal structures in [Laurence Harbor/ Union Beach] for purposes of reducing impact from hazards from storms, flooding or erosion?	yes	no						
[If so] Please tell me about the proposal/ project.	seawall	groin	flood gate	berm	bulkhead	comprehen sive project	beach replenishment	
How did you become aware of this project?	news	neighbor	government	see it	don't know	studied		

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Were you involved in project planning or community discussions?	yes	no						
What do you think of the project?	good	if works	okay	skeptical	not good enough	don't like		
Are there other projects?	seawall	groin	flood gate	berm	bulkhead	comprehensive project	beach replenish ment	
How did you become aware of this project?	news	neighbor	government	see it	don't know	studied		
Were you involved in project planning or community discussions?	yes	no						
What do you think of the project?	good	if works	okay	skeptical	not good enough			
[REPEAT]								
Do you know about any proposals to enhance natural environmental features in [Laurence Harbor/ Union Beach] to reduce hazards or impact from coastal hazards we have been discussing?	yes	no						
[Is so] Please tell me about the project.	wetland restoration	dune creation	beach replenishment	replanting	green acres buyout	comprehensive project		
How did you become aware of this project?	news	neighbor	government	see it	don't know	studied	organizat ion	

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Were you involved in project planning or community discussions?	yes	no						
What do you think of the project?	good	if works	okay	skeptical	not good enough	don't like		
Are there other projects?								
[Is so] Please tell me about the project.	wetland restoration	dune creation/ enhance ment	beach replenishment	replanting	green acres buyout	comprehensive project		
How did you become aware of this project?	news	neighbor	government	see it	don't know	studied	organizat ion	
Were you involved in project planning or community discussions?	yes	no						
What do you think of the project?	good	if works	okay	skeptical	not good enough	don't like		
[REPEAT]								
Finally, I'd like to ask you about the future.								

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
Thinking about the future, are there any projects or features you would prefer being used to reduce hazards or impact from hazards in [Laurence Harbor/ Union Beach]?	yes	no	don't know					
What would you prefer?	seawall	dunes	groins	bulkhead	wetland	grasses/ forest		
[If yes] Why do you prefer them?	work better	long term benefit	looks better	nature	scientists know			
Any existing coastal structures/ features you believe should be enhanced?	seawall	dunes	groins	bulkhead	wetland	grasses/ forest	comprehensive system	
[If yes] Why do you feel that way?	experience	nothing else has worked	learned about	trust				
Are there natural features or built coastal structures not here now that you would like to see for [Laurence Harbor/ Union Beach]?	yes	no	don't know					
Can you describe these?	seawall	dunes	groins	bulkhead	wetland	grasses/ forest		
If the features you prefer were built or enhanced, would they make [Laurence Harbor/ Union Beach] better?	yes	no	don't know					

Table C.1 (Continued) Interview Coding Sheet

	Data							
Interview Question	***potential codes or themes***							**Narrative Response**
In what way?	work better	long term benefit	looks better	more natural	clean			
Those are all the questions I have. Is there anything you would like to add?								

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