THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF FINANCE

LOCATION, LOCATION, INUNDATION: EXAMINING THE EFFECTS OF SEA LEVEL RISE ON CAPE MAY COUNTY, NEW JERSEY, BARRIER ISLAND REAL ESTATE

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SPRING 2019

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Finance
with honors in Finance

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ABSTRACT

Global average sea levels have swelled over eight inches over the last 120 years, with almost three of those inches gained in the past 20 years. These rising sea levels and increased incidences of extreme weather events can have destructive effects on coastal areas, including habitat loss for animals and humans, erosion, flooding, and soil contamination. This paper examines the effects of sea level rise on residential properties in coastal Cape May County, New Jersey, an area with exposure to rising seas and climate change that could force abandonment within the next century.

The paper first introduces historic trends and other factors that specifically influence Cape May County real estate's vulnerability to current and projected future sea level rise. It discusses how coastal real estate markets around the United States are currently underpricing the potential effects of sea level rise on properties and provides intuition as to why this topic is critically important to Cape May County. Additionally, the paper examines various projections for relative sea level rise along the southern New Jersey coastline based on numerous local influences and presents theoretical sea level rise scenarios over multiple time horizons. Based on these projections and local real estate data, the paper provides hypothetical value-at-risk estimates for each municipality in coastal Cape May County at the 2030, 2050, and 2100 horizons. While vulnerability of individual properties is subjective, the study provides theoretical estimates of flood tolerance and subsequent loss in value due to "effective inundation" of properties and communities.

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ACKNOWLEDGEMENTS

I would like to thank Dr. Christoph Hinkelmann and Dr. Brian Davis for their advice and encouragement during the creation of my thesis and their guidance throughout my college career. I would also like to thank my parents and family for supporting my endeavors and encouraging me to pursue an education from the Schreyer Honors College at Penn State.

Chapter 1

Introduction

The earth's average temperature has risen by 1.5°F over the past century and is expected to rise between 0.5°F and 8.6°F over the next 100 years (U.S. EPA, 2016). The increase in average temperature has coincided with changes in weather patterns, an increased severity of meteorological events, and climate change. The world's oceans are absorbing more than 90% of the increased atmospheric heat associated with emissions that result from human activity, and the oceans are also warming and becoming more acidic, causing land-based ice to melt and global sea levels to rise (U.S. EPA, 2016). Sea level rise (SLR) is widely considered the most severe result of climate change. To understand the factors driving SLR and how it will impact the infrastructure, economies and populations of different coastal locations, it is important to understand that seas rise at different rates around the world. As defined by Horton et al. (2018), relative sea level is the difference in elevation between the sea surface and the land, while the global mean sea level is the average of either relative sea level or sea-surface height over the global ocean. Global mean SLR is primarily driven by increased melting of glaciers and other land-based ice, warming of the oceans that results in thermal expansion, and changes in land water storage. The speed of global mean SLR increased during the second half of the 20th century and has continued to increase through the early 21st century. Due to forces such as ocean dynamics, atmospheric influences, and geological conditions, relative sea level rise and global mean sea level rise have varied in rate and magnitude over the earth's history. Seas rise

unevenly and sea surface heights vary by location, with SLR influencing some coastal areas more than others. For example, there is about a 30 cm difference in sea surface height between the New Jersey and North Carolina coastlines (Kemp, 2013).

The global mean sea level has climbed approximately 400 feet over the past 20,000 years and human interaction with the environment in recent centuries has rapidly increased the rate of global warming and thus SLR (Smithsonian, 2018). Further, higher sea levels are causing storm surges to push further inland than they did in the past. These higher storm surges are caused not only by more severe weather events but are also a result of full tides rising higher and encroaching further inland as sea levels continue to rise, which has caused nuisance flooding to be 300% to 900% more frequent in United States coastal communities than it was just 50 years ago (Lindsey, 2018).

High projections for future SLR have brought increased attention to the economic risks presented by climate change in coastal areas around the world. Areas with large socio-economic influence that are particularly vulnerable to SLR, such as Cape May County, are home to billions of dollars of at-risk real estate. While the long-term effects of SLR on coastal infrastructure, communities, and properties can only be known as time progresses, the vulnerability of communities can be evaluated using current scientific projections and localized analysis.

Chapter 2

Topic Overview

Cape May County, New Jersey

Cape May County (CMC) is located at the southernmost tip of New Jersey in the Atlantic Coastal Plain. Much of the county's landmass is on the Cape May Peninsula, which is bounded by the Delaware Bay on the west side and the Atlantic Ocean to the south and east. The county's most prominent geographical feature is a strip of five barrier islands, known as the "resort municipalities", where wetlands and tributaries separate the islands from the mainland to the west and the Atlantic Ocean sits to the south and east. Barrier islands are a very prominent feature of the New Jersey coastline, and the towns of Cape May Point, Cape May, the Wildwoods, Stone Harbor, Avalon, Sea Isle City, and Ocean City are the major barrier island towns in CMC.

Figure 1. CMC From Southern Point of the Cape May Peninsula (Cape May County, 2016)

The CMC resort municipalities[1] population swells from roughly 34,000 full-time residents to over 500,000 people in the summer months (U.S. Census Bureau, 2017), with tourists and seasonal residents traveling from the Greater Philadelphia Area, Northern New Jersey, and New York to the five barrier islands that lie adjacent to the mainland. Only 7% of the barrier island inhabitants are full-time residents and most of the homes along the five barrier islands are second homes and rental properties that are used primarily in the summer months (Cape May County Board of Tourism, 2016).

Tourism is deeply rooted in the history of the five barrier islands and residents of the town of Cape May refer to it as "the nation's oldest seashore resort". CMC generated $6.3 billion in tourism expenditures in 2017, which came primarily from the barrier island resort municipalities (Cape May County Board of Tourism, 2018). Additionally, tourism-related jobs account for 60% of the county's workforce (Cape May County Chamber of Commerce, 2018).

Vulnerability of Cape May County Resort Municipalities

The CMC environment is comprised of three unique areas: the mainland, the wetlands (49% of the county's geographical area), and the five barrier islands. Due to their low topographic elevation and tidally-influenced location between the Atlantic Ocean and wetlands, the barrier islands of CMC are particularly susceptible to extreme weather events and storm surge flooding. Barrier islands such as the CMC resort municipalities are inherently unstable, and the county's shore lines and beaches are continuously changing environments that are frequently reshaped by currents, storms, and SLR. The barrier islands not only change shape in

[1] Defined as the county's barrier islands along the Eastern edge of the county – Cape May Point, Cape May, the Wildwoods, Stone Harbor, Avalon, Sea Isle City, and Ocean City

response to natural events such as storms and tidal changes but are also altered by human efforts to develop them.

As the global ice mass shrinks, sea levels rise more in areas far distant from the initial melting point as mass reduction causes water to move away from melting ice sheets. The sea level is rising more rapidly along the Jersey Shore than the global average due to climate patterns and geological conditions that cause land subsistence (Miller et al., 2014). Due to ocean currents, water from Antarctica will move primarily to the Mid-Atlantic coast. According to Benjamin Horton, Principal Investigator with the Earth Observatory of Singapore, "The Mid-Atlantic coastline is the hot spot for the melting of Antarctica's ice.… The greatest sea level rise [from Antarctica's melting ice] will be felt in the Delaware Estuary and the Chesapeake Estuary" ("New Jersey Shore Sees Sea Level Change", 2018).

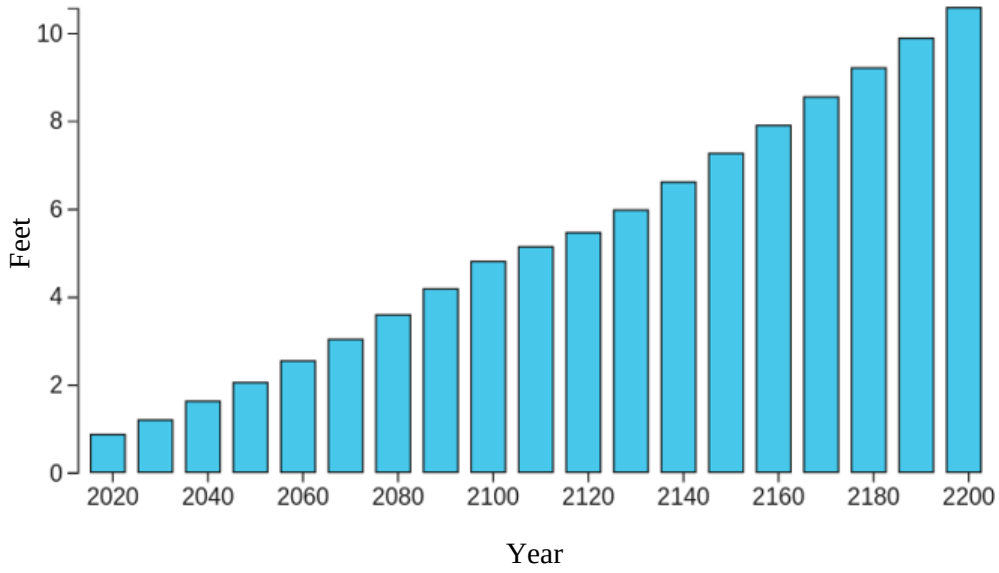
SLR influencing the position of the shoreline is not a new phenomenon; the coastline has moved landward by more than 75 miles over the last 200,000 years (Farrell et al., 2017). However, increased rates of land subsistence in the last century have magnified the impact of storm surges and other climate change related issues. Under a scenario where global carbon emissions are not significantly reduced over the next century, the global mean sea level could rise more than 6 feet by 2100 (Lindsey, 2018). If this occurs, the same areas of CMC that were flooded by Hurricane Sandy's storm surge would be inundated 26 times or more per year, or every other week on average (Spanger-Siegfried et al., 2017). According to the USGS Coastal Vulnerability Index, most of the coastline in CMC is ranked as High (35%) or Very High Risk (33%) in terms of relative susceptibility to SLR along United States' coastlines.

Superstorm Sandy in 2012 had a significant impact on the Jersey Shore and caused $29.4 billion in damage in New Jersey. Due to the 12-16 inches of SLR that occurred along the New

Jersey coastline during the 20th century, Sandy flooded an area 27 square miles greater than it would have if it occurred in 1880 (Miller et al., 2014). The same study found that based on an estimate of 1.5 feet of shore SLR by 2050 (using 2000 as a base year), a 1-in-10-year flood would exceed the highest level of Jersey Shore flooding experienced over the past decade. Although the financial loss and property damage from Hurricane Sandy in CMC was not as severe as losses in some northern New Jersey coastal areas due to storm movements and tides, CMC has experienced significant loss due to severe storms and flooding. For example, the town of South Cape May, located at the southern tip of the county, was washed away by nor'easters and hurricanes over a period of decades in the early 20th century, and was ultimately abandoned in the 1950s.

Recent studies including Strauss et al. (2014) suggest that New Jersey's coastal areas will experience SLR of between 12 and 28 inches by 2050. Under a worst-case scenario, these communities could see the sea-level rise as much as 2.8 feet by 2050 (Horton et al., 2018). If this scenario comes to fruition, the high-elevation areas of the New Jersey barrier islands would likely be spared from inundation in the next 30 years, but low lying areas with more significant exposures to tidal flooding would face intense flooding and would eventually have to be abandoned. While some of this rise can be prevented through a global reduction in carbon emissions, the ocean's response to warming is a slow process and researchers believe that most of the SLR that will occur before 2050 is already in the pipeline (Horton et al., 2018). Figure 2 shows a projection for New Jersey SLR based on the Intermediate Scenario from NOAA Technical Report NOS-OPS 083 (2017). Additional factors that contribute to local SLR and the various scenarios that these factors influence will be introduced in Chapter 4.

Figure 2. Southern New Jersey SLR Projections (from Climate Central, 2019)



Sea Level Rise Mitigation Efforts

Coastal areas around the world are continually employing infrastructure projects to combat rising seas and fight higher storm surges, and the CMC barrier island communities have been actively trying to mitigate the effects of climate change and human interaction with the environment for decades. As of early 2019, the state of New Jersey is planning over $2 billion in efforts to keep seas at bay including seawall construction, restoration projects, and catastrophic flood prevention tactics.

According to a 2017 UCS report, most community-level defensive efforts to keep water out are designed to minimize wave action, protect against storm surges and reduce erosion, but not to keep out normal higher tides. Seawalls, levees and other structures would need to be constructed along long expanses of shoreline to defend large areas from chronic inundation

(NRC, 2014). These manmade structures can exacerbate the issue of coastal erosion as the sea level continues to rise, and seawater can often infiltrate below and around these structures (Vitousek et al., 2017). Further, efforts to protect individual properties, such as elevating existing homes using stilts and weatherproofing lower levels of residences are very costly and fail to address the inundation of roads and other taxpayer supported works such as sewer systems.

As Dahl et al. (2017) concluded, if chronic flooding begins to engulf vacation municipalities, they could be visited less often than in the past, resulting in reduced government revenues. The defensive measures used to fight inundation from flooding and SLR are extremely capital intensive and attempting to fund the projects with diminished tax revenues (caused by inundated properties and declines in tourism revenues) could create a push-pull situation. Additionally, the ability to get debt financing for projects that fight SLR flooding could be hindered by lower credit ratings of municipalities due to chronic flooding risks.

Many of the tactics currently being employed are temporary fixes for a permanent problem and are not sustainable indefinitely. Stanford University coastal policy researcher Anne Siders claims that, “We have hidden the true risk of living on the coast for a long time with government policies” (“Beach Replenishment's Future”, 2018). For example, the United States federal government has historically subsidized 2/3 of beach replenishment costs, but as McNamara et al. (2015) noted, a sudden removal of federal [beach] nourishment subsidies, as has been proposed in the past by the federal government, could trigger a “dramatic downward adjustment in coastal real estate”. Some ongoing efforts by communities to fight SLR have been unsuccessful over the long term. For example, in a January 2019 interview with a local New Jersey radio station, Jeff Tillel, director of the New Jersey Sierra Club, claimed that the state of

New Jersey's response to climate change so far has been flawed; "We put in groins and jetties and seawalls, and we pump a lot of sand, and all the things we're doing really aren't working. Every time there's a storm, we see millions of dollars of sand going out to sea." (Flammia, 2019).

Chapter 3

Sea Level Rise as a Market Force

Sea Level Rise and Real Estate Values at the National Level

The contiguous United States' 13,000 miles of coastline are now the most densely populated regions of the country, with the 40% of Americans that live in and visit coastal shoreline counties contributing $7.9 trillion to the United States GDP (NOAA Office For Coastal Management, 2017). The coastal region is host to some of the highest property values in the country, and billions of dollars of infrastructure lie in the path of rising seas. As the sea level continues to rise, coastal communities will face more frequent and severe flooding and unless carbon emissions are reduced significantly and scaled efforts are undertaken to fight SLR, large portions of United States coastal real estate could be permanently underwater within the next century. Although there is a consensus in the scientific community regarding increased coastal flooding and rising sea levels, real estate values in most coastal property markets have yet to fully reflect this significant long-term risk. According to research from Zillow, 1.9 million homes in the United States are projected to be underwater by 2100 if the global mean sea level rises six feet, a number midway between the conservative estimate of 4.3 feet and a "cannot be excluded" prediction of 8 feet. That accounts for $916 billion of real estate and 1.8% of the housing stock (Bretz, 2017).

Recent studies have also estimated the value of United States coastal property that has already been eroded by SLR. Currently, residential properties in the United States that are exposed to rising sea levels sell on average for 7% less than unexposed properties that are

equidistant to the shore. This discount has grown over the past two decades and is driven by sophisticated buyers who are worried about the effects of SLR and climate change (Bernstein, Gustafson & Lewis, 2017). Further, increased tidal flooding erased $14.1 billion in relative home value through eight states between 2005 and 2017. In the state of Florida, rising sea levels have wiped out $5.4 billion of relative value since 2005 (First Street Foundation, 2018). Keenan, Hill and Gumber (2017) found that homes at lower elevations in Miami-Dade County are not only selling for less relative to otherwise identical homes at higher elevations, but also gaining less in value at a slower rate than the homes with less exposure to SLR.

While there is evidence supporting SLR exposure being priced into coastal real estate sales to a small degree, multiple studies have found that current home prices do not reflect the full extent of future SLR projections. Further, researchers have found that many market participants base their expectations of future flooding and SLR on outdated perceptions. Official Federal Emergency Management Agency (FEMA) flood maps, which are often looked to for guidance on flood exposure and insurance risk, are backwards-looking and one in six maps are over 20 years old (Bakkensen & Barrage, 2017). Dynamic housing market models show coastal prices currently exceed fundamentals by 10%, and when heterogeneity of expectations is ignored, modelers may be underestimating coastal home price declines due to SLR by a factor of four over the next 25 years (Bakkensen & Barrage, 2017).

Cape May County Real Estate Market

In the late 1990s and early 2000s, the CMC resort town real estate market experienced a price boom. For example, the average price of a home in Ocean City, New Jersey, went from

$110,000 in 1990 to a peak of $415,000 in mid-2006, which significantly outpaced much of the United States housing market (Zillow Data, 2019). This trend was found in each of the CMC barrier island communities, where small beach cottages that dotted the streets of many of the towns were replaced with duplexes and year-round populations decreased significantly. While the price boom subsided with U.S. housing market declines in the late 2000s, barrier island properties are still considered to be some of the most expensive in the state of New Jersey per square foot.

Table 1. Cape May County Barrier Municipality Median Price and Housing Stock

Barrier Municipality	Median Home Value[3] (January 2019)	Total Housing Units[4]
Avalon	$1,488,100	5,342
Cape May	$598,000	4,856
North Wildwood	$346,800	8,819
Ocean City	$596,800	19,946
Sea Isle City	$719,000	6,842
Stone Harbor	$1,559,100	3,143
West Cape May	$543,700	1,062
West Wildwood	$195,700	888
Wildwood	$229,100	7,381
Wildwood Crest	$373,000	5,500

Due to the New Jersey coast's vulnerability to the melting of Antarctic ice sheets and the resort municipalities' positions as barrier islands with low elevations, the CMC resort town properties are particularly exposed to SLR, and expectations of SLR have begun to influence home values. Ocean City consistently ranks as one of the towns most affected by climate change in the United States. For example, a February 2019 study published by the First Street

[3] Source: Zillow Group
[4] Source: American Community Survey (2017)

Foundation found that Ocean City real estate has lost more in potential increases in property values since 2005 ($531 million) than any other town on the Eastern Seaboard.

Although most homes in the CMC resort municipalities are appreciating in value, they are doing so at a lower rate than comparably unaffected homes. A 2018 Wall Street Journal report found that homes in neighboring Ocean County, New Jersey, a coastal county with similar geodemographic classifications as CMC, the value of high-risk flood-zone homes rose 1% between 2012 and the end of 2017, while the value of inland homes rose 26% (Krouse, Kusisto & McGinty, 2018).

The study in Chapter 4 aims to quantify the potential future loss in value from CMC barrier island properties that must be abandoned or repurposed as a result of inundation from chronic flooding and rising seas at different time horizons. Mortgages on homes that are projected to be chronically inundated are riskier, and as flooding becomes more severe, many homeowners will have mortgages that exceed the value of their house. On top of this, these homes will begin to become unlivable and very difficult to insure. Flood insurance for chronically inundated coastal properties could become increasingly expensive or not available at all (FEMA 2018; Lieberman 2017). If a home that was purchased at the time this paper was written with a 30-year mortgage was projected to be inundated by 2050, the area's current use would no longer be practical under the definition of chronic inundation and the property value would likely be significantly impacted.

Chapter 4

Analyzing Erosion of Value in the Cape May County Housing Market

Methodology

Most studies that focus on the effect of SLR on coastal property values use blanket estimates of SLR that cover large areas, such as global mean sea level rise projections. For example, the 2017 Zillow Group study cited in Chapter 2 used a blanket estimate of 6 feet of SLR by 2100 across the United States to approximate the impact of climate change on property values. These estimates do not always incorporate factors that influence how SLR will affect specific locations, such as local meteorological and geological conditions. In addition to local influences, there is a large range of projections of future SLR from researchers with different methodologies and factor inputs, and the range grows even larger at longer time horizons. This study aims to mitigate these factors by consolidating research that focuses on CMC and incorporating local influences and regional SLR estimates. These estimates are key to making reliable projections over multiple time horizons, which can provide a more detailed view than studies that use blanket estimates of global SLR.

The study first maps out various potential local climate change situations over different time horizons (2030, 2050, 2100) and aligns these with the four potential Representative Concentration Pathways (RCPs**)** that the Intergovernmental Panel on Climate Change (IPCC) created for climate change research. The study then consolidates estimates from various recently published academic studies that focus on the New Jersey and CMC area to provide a hypothetical average estimate at each time horizon.

In line with the definition of effective inundation established in Dahl et al. (2017), the study then approximates how many homes in each CMC resort municipality will be inundated at each horizon based on their elevation relative to the Mean Higher High Water[5] (MHHW) level, and provides a hypothetical estimate of the total present day value of the homes that will be potentially lost or severely impaired due to inundation based on January 2019 estimates from the Zillow Home Value Index (ZHVI)[6]. While this methodology cannot directly relate the value lost from individual homes relative to their elevation, it provides a theoretical approximation that is suitable for purposes of this study and is used for reasons discussed later in Chapter 4.

Cape May County Barrier Island Sea Level Rise Projections

As emphasized in Horton et al. (2018), projecting future global SLR relies on an understanding of what drives the earth's spatio-temporal evolution, which involves various factors and can be very difficult to project. Additionally, location-specific relative sea levels can change in response to more localized factors such as geological influences (including erosion, sediment compaction and tectonic changes along coastlines) that influence regional SLR. The majority of 20th century rise, including most global mean SLR during the last quarter of the 20th century, is tied to anthropogenic, or human-caused warming. When analyzing how future global warming will contribute to climate change, key factors such as future carbon emissions, as well as changes in energy production, technological advancements, population growth, and land use

[5] The average of the higher high-water height of each tidal day observed over the National Tidal Datum Epoch (NOAA Tidal Datums Glossary)
[6] A time series tracking the monthly median home value in a particular geographical region (Zillow Group)

must be considered. Table 2 summarizing these major influences can be found below. Note that the region-specific factors in Table 2 were sourced from Kaplan et al. (2016).

Table 2. Factors Contributing to Cape May County SLR

Global Factors
1. Thermal expansion of ocean water
2. Mass loss from the melting of land-based ice including glaciers, ice caps, and ice sheets
3. Changes in land water storage
Additional Factors Relevant to CMC Barrier Islands (Kaplan et al., 2016):
1. Glacial isostatic adjustment (GIA), of about 0.5 inches per decade across the region
2. Vertical land motion due to natural sediment compaction and groundwater withdrawal along the Coastal Plain, reaching up to about 0.4 inches per decade along the Coastal Plain
3. Changes in ocean circulation and winds, and associated changes in the distribution of heat and salt within the ocean, which may add about 1 foot per century in the U.S. Northeast under high emissions scenarios
4. Static-equilibrium effects (changes in the height of Earth's gravitational field and crust associated with the large shifts of mass from ice to the ocean)

To begin the study, estimates of regional SLR in southern New Jersey using different assumptions at multiple horizons must be established. With this data, theoretical central point estimates of SLR can be made at various time periods in order to conduct an analysis of the effects of future SLR on CMC barrier island real estate. In order to juxtapose research from different groups, the Intergovernmental Panel on Climate Change (IPCC) created a standard set of scenarios that provide baseline conditions, projections and historical conditions. These scenarios are known as Representative Concentration Pathways (RCPs**)**. There are four

pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6. The last pathway is also referred to as RCP3-PD.

Recent research that uses these pathways to predict SLR over various horizons was used to establish central point estimates at three different time horizons (2030, 2050, and 2100) from a baseline year of 2000. While this sample size is not large enough to be statistically significant, the average estimates can be used to illustrate the potential impacts of SLR on homes projected to be effectively inundated.

Table 3. Cape May County SLR Scenarios Under Various Emissions Pathways[7]

Representative Concentration Pathway (RCP)	Description	Assumptions	2030 Estimate	2050 Estimate	2100 Estimate
RCP8.5	High-emission pathway with continued growth of CO2 emissions	Global annual GHG emissions (in CO_2-equivalents) continue to rise throughout the 21st century	~1.4 ft of SLR	~2.3 ft of SLR	~5.9 ft of SLR
RCP6	Moderate-emission pathway with increasing emissions	Emissions peak around 2080, then decline	~1.0 ft of SLR	~1.9 ft of SLR	~4.9 ft of SLR
RCP4.5	Moderate-emission pathway with stabilized emissions	Emissions peak around 2040, then decline			
RCP2.6 (RCP3-PD) peak and decline	Low-emission pathway consistent with the Paris Agreement's goal of net-zero CO2 emissions in the second half of this century	Emissions peak between 2010–2020, with emissions declining substantially thereafter	~0.6 ft of SLR	~1.1 ft of SLR	~2.5 ft of SLR
Central Projection	Most Likely Estimates		~1.0 ft of SLR	~2.0 ft of SLR	~4.9 ft of SLR

[7] Estimates are an aggregate average of data from 2013-2017 studies including: (a) Kopp et al. (2016) https://doi.org/10.1073/pnas.1517056113 (b) Dahl, KA (2017) http://doi.org/10.1525/elementa.234 (c) Miller et al. (2013) https://doi.org/10.1002/2013EF000135 (d) NOAA Technical Report NOS CO-OPS 083 (2017)

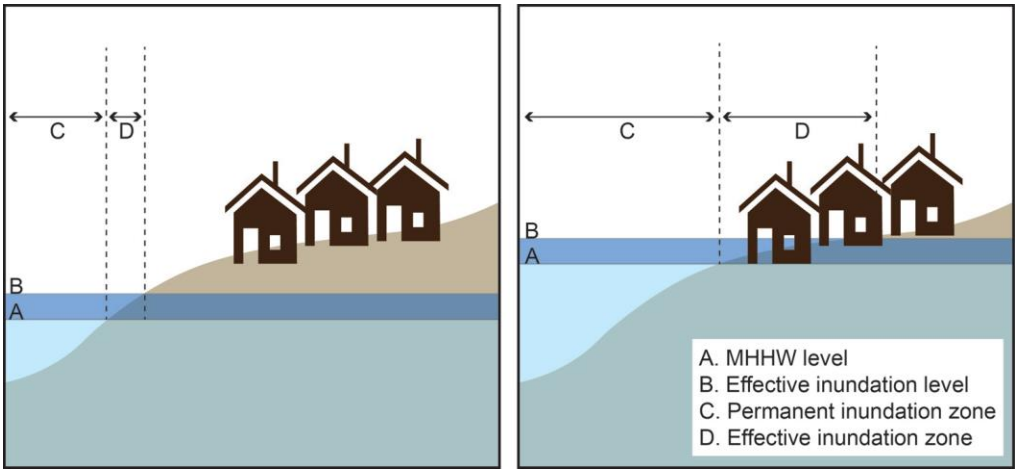
Defining Inundation

The methodology used to define effective inundation in this study is based on Dahl et al. (2017):

> We consider an effectively inundated area to be one in which flooding is so frequent that it renders the area's current use no longer feasible. In this sense, effective inundation is the point at which a community is forced to make changes to ensure its residents are safe and its infrastructure and services are functional. Effective inundation exists along an inundation trajectory that begins with no tidal flooding, then shifts as sea level rises to infrequent tidal flooding, then advances further into frequent tidal flooding, which becomes effective inundation, and eventually, permanent inundation.

Figure 3 from Dahl, KA (2017) considers areas below the Mean Higher High Water (MHHW) level today, that would be inundated by flooding at least once daily "permanently inundated". Areas that lie above the MHHW level are considered "effectively inundated" as they flood regularly enough (at least 26 times per year) that their use is limited.

Figure 3. Effective Inundation of Properties Relative to Local MHHW level (Dahl et al., 2017)



Although the MHHW level could be adjusted upward as the sea continues to rise, the CMC island communities will still flood at the same water level as in the past, which will lead to more frequent flooding to the point that areas could be essentially unusable. In line with a widely cited 2018 Union of Concerned Scientists Study, this study considers "effectively inundated" properties as at risk of chronic flooding and considers these properties "at risk" of potential future loss in value. Mortgages on the homes become riskier and homeowners could have mortgages that significantly exceed the current values of their homes. Likewise, if most of a community is effectively inundated at a specific horizon, the community would face significant challenges to continue to operate successfully.

Erosion of Value in the Cape May County Market

After local SLR is estimated at different time horizons, elevation data can be used to analyze the number of homes that are theoretically "at-risk" of effective inundation in each of the CMC barrier islands, and the total value of these homes in each barrier island municipality can be estimated based on the criteria established previously in Chapter 4.

Zillow Research's ZTRAX database has comprehensive data on the variables in this study and is frequently cited in studies related to property exposure to SLR. We attempted to get data from Zillow ZTRAX that would allow for a more comprehensive analysis and formal hypothesis testing, but the data is typically only accessible to researchers at the PhD candidate level and above, and multiple attempts to get access to the database were unsuccessful. Without access to ZTRAX data, the inundation value estimates in this study are theoretical in nature rather than empirical.

As noted in the methodology above, the number of homes in each CMC resort municipality that will be inundated at each time horizon (2030, 2050 and 2100) is approximated based on their elevation relative to the Mean Higher High Water (MHHW) level. With this information, a hypothetical estimate of the total value of all homes (using 2019 as a base year) that will be effectively inundated is found using a time series tracking of monthly median home prices from January 2019 (sourced from Zillow).

This method makes several assumptions that must be addressed. Primarily, it assumes that geographic exposure to SLR is relatively evenly dispersed within each community (i.e. homes in each barrier island community are fairly homogenous in terms of value). An analysis of elevation and flood maps along the barrier islands as well as an analysis of sales data shows that exposure to varying levels of SLR tends to be spread throughout the different "price levels"

of the islands and different geographic areas. Standardized lot sizes and building codes within most of the CMC resort municipalities help further mitigate this issue. Likewise, it assumes that SLR is not fully priced into the market at the current time. While studies including Bernstein, Gustafson and Lewis (2017) have shown that there is currently a small discount priced into United States coastal real estate markets to account for exposure to SLR, other studies such as Bakkensen and Barrage (2017) have found that the current discount is a recent phenomenon that only reflects a small fraction of the potential for SLR to erode market value in the future.

Note that based on the availability of reliable data on the approximate number of homes in each municipality at elevation increments, the SLR estimates in the figures below for the year 2100 are rounded from 4.9 feet to 5 feet.

Table 4. Homes Inundated at Each SLR Horizon

Barrier Island Municipality	Estimated Total Housing Units[8]	Homes Inundated by 2030[9] (~1 ft)	Homes Inundated by 2050 (~2 ft)	Homes Inundated by 2100 (~5 ft)
Avalon	5,342	38	143	3,785
Cape May	4,856	22	49	2,273
North Wildwood	8,819	123	1,364	7,739
Ocean City	19,946	111	1,124	14,355
Sea Isle City	6,842	64	256	5,297
Stone Harbor	3,143	26	194	2,047
West Cape May	1,062	0	10	420
West Wildwood	888	464	810	883
Wildwood	7,381	107	794	6,408
Wildwood Crest	5,500	17	54	3,711
TOTAL	63,779	**972**	**4,798**	**46,918**

Table 5. Value of Inundated Homes at SLR Horizons

Barrier Island Municipality	Estimated Total Home Value	Value of Homes Inundated by 2030 (~1 ft)	Value of Homes Inundated by 2050 (~2 ft)	Value of Homes Inundated by 2100 (~5 ft)
Avalon	$7,949,000,000	$56,000,000	$213,000,000	$5,633,000,000
Cape May	$2,903,000,000	$13,000,000	$30,000,000	$1,359,000,000
North Wildwood	$3,058,000,000	$43,000,000	$473,000,000	$2,684,000,000
Ocean City	$11,904,000,000	$68,000,000	$671,000,000	$8,567,000,000
Sea Isle City	$4,919,000,000	$46,000,000	$184,000,000	$3,808,000,000
Stone Harbor	$4,900,000,000	$42,000,000	$303,000,000	$3,192,000,000
West Cape May	$577,000,000	$0	$5,000,000	$229,000,000
West Wildwood	$174,000,000	$91,000,000	$159,000,000	$173,000,000
Wildwood	$1,691,000,000	$25,000,000	$182,000,000	$1,468,000,000
Wildwood Crest	$2,052,000,000	$6,000,000	$20,000,000	$1,384,000,000
Total	$40,127,000,000	**$387,000,000**	**$2,238,000,000**	**$28,497,000,000**

[8] Source: 2017 American Community Survey
[9] Source: NOAA elevation data

Table 6 uses a sensitivity analysis to provide wider ranges (50% to 150%) of the potential total value-at-risk of effective inundation across all the CMC barrier island municipalities. Central estimates for the 2030, 2050, and 2100 horizons are highlighted in yellow. Note that the maximum potential loss is $40.129 billion (based off 2019 home values), which would indicate a total loss and abandonment of all CMC barrier islands due to chronic inundation.

Table 6. Sensitivity of Potential Loss Due to Effective Inundation in CMC Resort Municipalities (in millions)

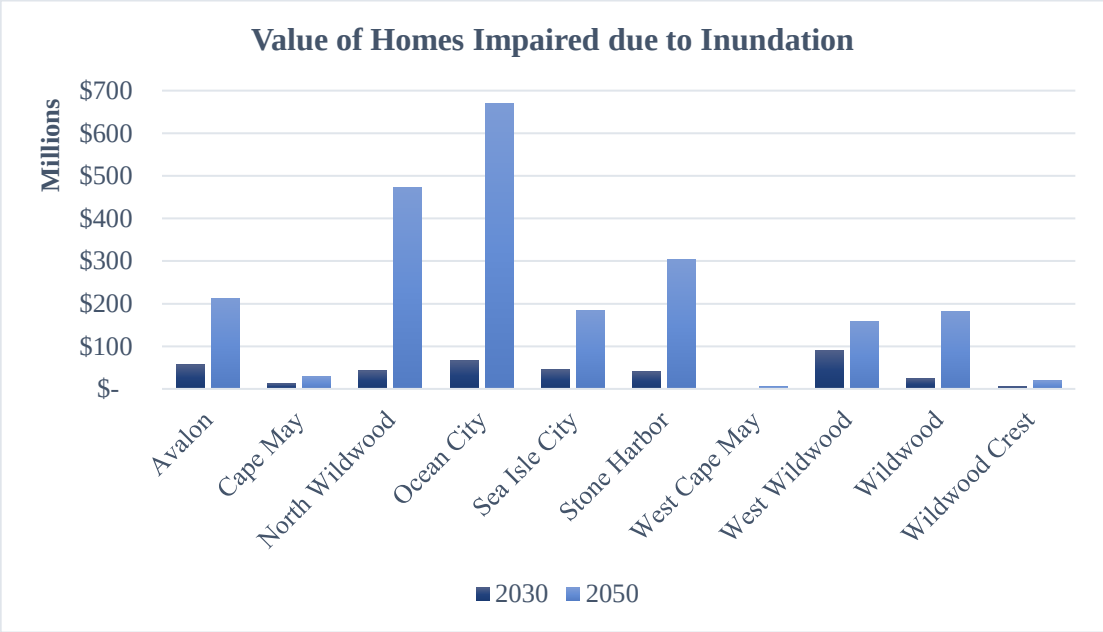
	1 Foot	2 Feet	3 Feet	4 Feet	5 Feet	6 Feet
1.5x	$580	$3,358	$14,666	$32,222	$40,129	$40,129
1.25x	$483	$2,798	$12,222	$26,852	$35,622	$40,129
Central Estimate	$387	$2,238	$9,778	$21,482	$28,497	$33,176
0.75x	$290	$1,679	$7,333	$16,111	$21,373	$24,882
0.50x	$193	$1,119	$4,889	$10,741	$14,249	$16,588

The increase in value-at-risk from the 2050 horizon to the 2100 horizon is very large, and Figure 4 breaks out estimates from 2030 and 2050 in order to provide more clarity with the near-term projections. Note the drastic increase between 2030 and 2050 in all municipalities, which is most notable in Avalon, North Wildwood, Stone Harbor, Ocean City, and Sea Isle City. These results are consistent with a 2017 study that analyzed effective inundation around the United States and found that New Jersey will experience a large increase in effectively inundated communities between 2030 and 2045—from 26 communities to 55 communities (Dahl et al., 2017).

As illustrated in Table 5, central estimates indicate that the CMC property value-at-risk of inundation significantly increases from the 2050 horizon to the 2100 horizon, which is due to both a large increase in the number of homes at exposed elevations and higher expectations for

SLR over the extended horizon. The following sub-section of this chapter provides a more detailed analysis of the increase.

Figure 4. Projected Loss Due to Effective Inundation at 2030 and 2050 Horizons

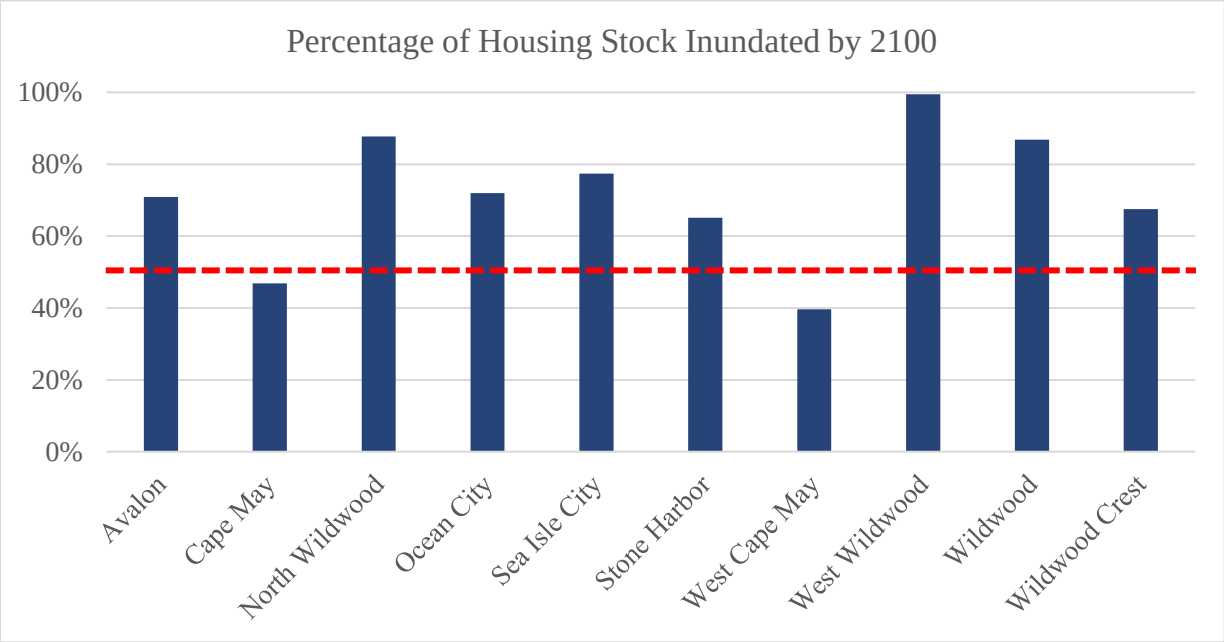


Assessing Inundation by Year 2100

Even if some individual homes avoid effective inundation at the 2100 horizon, the large number of homes at risk could cause each neighborhood to collectively experience significant property value declines as major parts of communities become unusable (Dixon et al. 2017). As discussed in Dahl et al. (2017), if most of the homes in a community are inundated by chronic flooding, roads, public works and other services will be troubled by a significantly decreased tax base and a decline in tourism. The lower tax base will further hinder municipalities infrastructure projects and other efforts to fight SLR. As illustrated in Figure 5, eight of the ten barrier island municipalities in CMC are projected to be chronically inundated by 2100 based on

a chronic inundation benchmark of 50% of all community homes (noted by the dashed red line in the chart). These communities will face significant challenges to continue operations and while the value of homes projected to be inundated by 2100 in Appendix A is significant, it does not account for collateral damage to other community properties caused by widespread chronic inundation, which could potentially increase the value-at-risk across all of the CMC resort towns by year 2100 from $28.5 billion to close to $40 billion. These findings are in line with Dahl et al. (2017), which assessed community-level vulnerability to effective inundation across the United States and found significant risk of chronic inundation in CMC at similar horizons.

Figure 5. Projected Chronic Inundation by 2100



Chapter 5

Conclusion

Sea level rise has the potential to drastically reshape coastal areas around the world and destroy trillions of dollars of real estate in the process. Even if significant cuts to carbon emissions in line with the Paris Agreement are achieved over the next few decades, most of the sea level rise that will occur within the next 30 years is already in the process of occurring and is essentially unavoidable. Some stakeholders cite manmade mitigation efforts and adaption measures in order to discount the financial impact of current and future sea level rise on communities, but these are extremely costly measures that could become even more challenging to implement as tax bases in coastal areas are impaired due to inundation and weather risks hinder the ability to secure debt financing and subsidies for these projects. Although this paper focuses on Cape May County real estate's vulnerability to SLR, this is a global issue that must be placed at the forefront of public policy decisions.

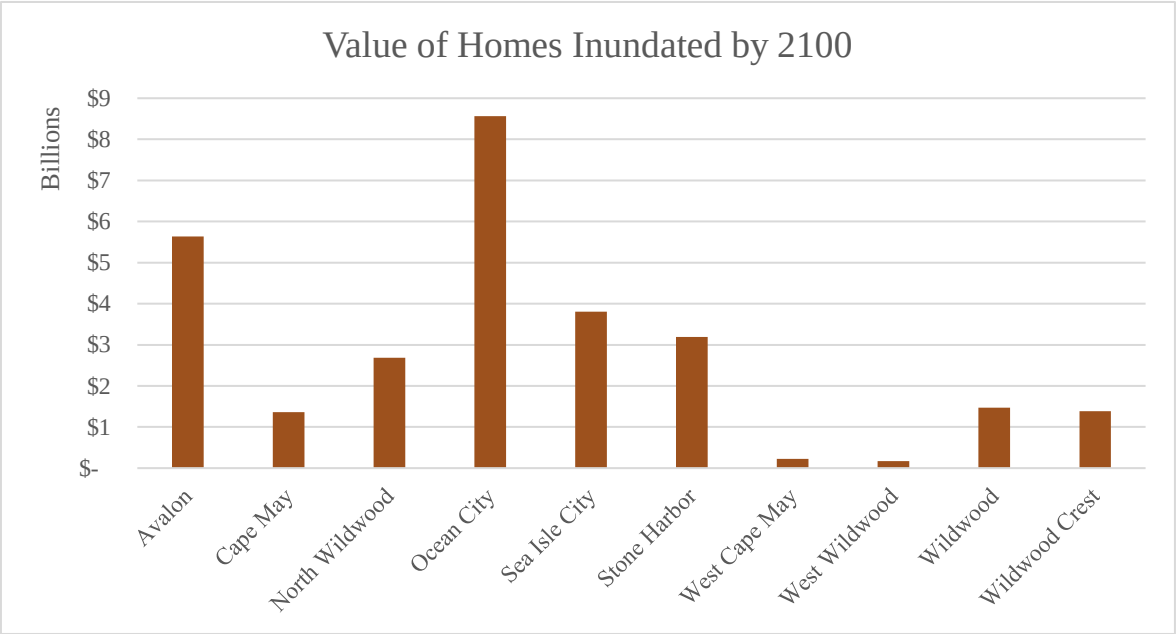
While the results in Chapter 4 provide realistic approximations of the property value-at-risk of inundation due to SLR, the estimates do not fully reflect future developments in adaption measures and additional changes in the area. Because of this, the results may under or overestimate the number and value of properties projected to be inundated at each horizon. However, as noted in the *Sea Level Rise Mitigation Efforts* sub-section of Chapter 2, adaption measures may not be effective in dampening the effects of SLR and climate change in the area over the long term.

One area of possible further investigation and a significant takeaway from this study is the potential for default on mortgages associated with the homes at risk. When considered in the context of purchasing a home in 2019 with a 30-year mortgage, there are roughly 5,000 homes worth an estimated $2.2 billion in the CMC towns studied that could be influenced such that the remaining mortgage payments surpass the value of the homes at some point in the next 30 years. Currently, the main determinant of risk in the mortgage market is the credit risk of borrowers, and weather risk is not typically a primary consideration. Further, when insurers do factor weather risks into their decisions, the industry standard is to use FEMA flood maps as a gauge, and the FEMA maps can be flawed as a risk assessment tool due to inaccuracy, outdated estimates, and other reasons discussed in Chapter 2. As SLR continues to inundate properties and communities, borrowers may decide to abandon homes that they cannot afford to pay off or they no longer want to live in, creating a crisis for government agencies and mortgage financiers which could ripple through the larger economy.

While the full extent of losses in the CMC real estate market will not be known for decades to come, recent research and projections for the future paint an unnerving picture for residents, mortgage issuers, local governments, and other market stakeholders. Further, an analysis of current market conditions and government policies suggests that the CMC market and other coastal real estate markets are reactive rather than proactive when dealing with SLR, which must be changed in order to avoid a crisis in the future.

Appendix A

Current Value of Homes Projected to be Inundated by 2100



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ACADEMIC VITA

Dillon Kelly

PROFESSIONAL EXPERIENCE

Goldman Sachs **Philadelphia, PA**
Summer Analyst – Investment Management Division June 2018 – August 2018

- Researched and analyzed investment strategies across asset classes including public/private equity, fixed income, derivatives and other alternatives for clients including ultra-high net worth individuals, families and foundations
- Prepared client deliverables such as asset allocation and portfolio performance as well as internal performance/strategy deliverables
- Received an offer to return to Goldman Sachs full-time upon graduation

Johnson & Johnson **Horsham, PA**
Finance Intern – Janssen Pharmaceuticals June 2017 – August 2017

- Developed and owned a model that tracks reserves to allow for comprehensive performance analysis at the SKU level
- Leveraged model to gain visibility into profits implied by the model vs. collected profits to identify potential areas of improvement resulting in significant potential cost savings for J&J
- Received a J&J "Encore Award" for special achievement in planning and delivery

Exeter Property Group **Conshohocken, PA**
Intern Analyst – Multifamily Sector March 2016 – August 2016

- Provided analytical support for a start-up division of an international real estate development company, including the compilation of comprehensive reports for potential acquisitions, new development, and equity raises
- Organized data for private equity raises to support acquisitions and performed detailed analysis of rent comparisons, area demographics, and other relevant information for presentation to investors

LEADERSHIP AND INVOLVEMENT

Penn State IFC/Panhellenic Dance Marathon **University Park, PA**
Group Chair September 2015 – Present

- Partnered with a fellow student chair to raise $6300+ for THON 2019 through canvassing, online fundraisers, and alt fundraisers
- Organized and led alternative fundraisers such as basketball tournaments to fundraise in the fight against pediatric cancer

Sapphire Leadership Program **University Park, PA**
Member August 2015 – December 2018

- Represent top 5% academically of Smeal College of Business incoming class as a part of a 50-member cohort that engages in academic seminars and practical professional experiences
- Shape student leadership in business through participation in corporate, fundraising, and community service events designed to improve communication and management skills

Penn State Interfraternity Council **University Park, PA**
Active Member / IFC Standards Committee Member August 2016 – December 2017

- Acquired a four-figure donation from fraternity alumni and used it to promote improved academic achievement by designing and converting a previously unused storage room in the chapter house into a 14-seat study library with A/V capabilities
- Participated in a select group of Penn State fraternity members who oversee the improvement of the Greek system through the creation and enforcement of rules and regulations

Wall Street Boot Camp I & II **University Park, PA**
Member / Student January 2017 – December 2017

- Selected from hundreds of applicants to participate in 40 student, semester-long Wall Street training programs

Penn State Investment Association **University Park, PA**
Member January 2017 – Present

Travis Manion Foundation Doylestown 9/11 Heroes Run **Doylestown, PA**
Committee Member August 2012 – August 2015

- Organized student volunteers and met with business representatives to acquire corporate sponsorships for 3000+ runner 5k race

HONORS AND INTERESTS

- Passed CFA Level 1, December 2018 Exam (45% pass rate)
- U.S Lacrosse High School Academic All-American, Suburban One Sports "Athlete of the Week", Keystone Boys State Delegate
- Penn State Club of Bucks County Senior Scholarship, Washington Crossing Foundation Scholarship, VFW Post 175 Scholarship