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Collateral Analytics™

# The Impact of Waterfront Location on Residential Home Values Considering Flood Risks

**Abstract:** Here we use a large dataset of residential property sales and attributes to re-confirm the significant premiums for waterfront proximity, more so for oceans, bays and large lakes than rivers. We also examine the price trends immediately before and after major storms in a few selected markets. It appears that the prices rebound rather quickly, with few long-term persistent impacts on value. It may be that insurance proceeds immediately help restore these markets and or that the lack of supply following a storm helps offset the otherwise dampened prices one might expect. In an attempt to use elevation as a proxy for flood risks, we find inconsistent evidence that the market perceives the risks of floods and discounts property prices. We also find little evidence of concern over sea level rise, as of 2018, despite the recent release of the Intergovernmental Panel on Climate Change (IPCC) report suggesting myriad and monumental consequences on the horizon. The lack of a significant and permanent market reaction may change as insurance premiums rise or other tangible evidence of the risks is made real. Our results suggest either a short-term horizon for buyers of coastal properties at risk, or a moral hazard problem whereby residential owners are dependent upon and subsidized by government and mispriced flood risk insurance premiums.

**Keywords:** Climate Change, Sea Level Rise, Flood Risks, Property Values

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# The Impact of Waterfront Location on Residential Home Values

# Considering Flood Risks

**Introduction: Part 1**

The following discussion examines the impact of water proximity on residential property values in two parts. In the first, we examine general premiums relative to the type of waterfront using a longitudinal and cross-sectional sample of property in markets across the US. In part two, we focus specifically on elevation and flood risk to try and replicate some of the suggested negative effects found by analysts within recent literature.[1]

There are many known influences on property value, such as size, age, property condition, school quality, and more, as examined in a list of papers too long to list here, with a methodology first described by S. Rosen. [2] Since that 1974 paper there have been hundreds, if not thousands, of articles covering the nuances of locational influences on property value from power lines to trees to open space and of course, waterfront proximity. Here we confirm and re-examine the empirical evidence on the impact of water proximity, but then we explore flood risk as a newer consideration within the literature.

Water frontage has a historically had a strong positive influence on location value, but in recent years, with global climate warming and greater flood risks, the question arises whether such negative influences offset the positive. That is a question we address in the second part of the discussion below, and we needed to first replicate the net positive premiums in order to put the second part of this study into context. Here we start with a rather large database of waterfront properties to analyze the general empirical impact on value. We use an advanced GIS (Geographic Information Systems*)* technique to identify and analyze data on approximately 1.2 million waterfront residential properties in the United States as of 2018. We combine this with several million transactions in the same zip codes to estimate net waterfront effects on value. We say net because there could be negative influences from flood risk perceptions and positive influences from proximity to water at the same time.

While waterfront and unspoiled views are undoubtedly a cherished attribute, not all water is the same. For example, one of the attributes that makes waterfront valuable is the view. However, each parcel will have a different view and the quality of this view will vary even in close proximity to the water. Other examples where the utility of waterfront and its impact on value vary could be water depth (for swimming or boating opportunities), water quality and purity, sound quality (such as the sound of breaking waves or the beating of pelican wings), the type of and color of water (lake, ocean, river, stream), fishing quality and access, and even the temperature of the water or air, as air temperature is stabilized by proximity to water. Tests of waterfront premiums for the nation as a whole in the year 2018 indicate that waterfront does have a substantial premium, but that it varies by the type of water (ocean, lake or river). Here we review those general differentials.

[1] For example, First Street Foundation found that 820,000 homes across the US are priced at a discount due to coastal flooding amounting to a US $14 billion loss since 2005, mostly from tidal flooding. See a variety of press releases at https://firststreet.org/press

[2] Sherwin Rosen's paper is one of the most cited early works establishing the hedonic method to value property. See "Hedonic Prices and Implicit Markets' Product Differentiation in Pure Competition," Journal of Political Economy, 1974, 82: pp. 34-55.

**Prior Research on Waterfront Premiums**

A recent study on the impact of proximity to water by Jan Rouwendal, Or Levkovich and Ramona van Marwijk (2017)[3] argues that waterfront properties get an upward-biased coefficient of impact based on the correlation of waterfront locations with high quality home features. They compare home values for identical houses, at various distances from water. Their results show a significant impact of waterfront, but a smaller impact than many earlier studies when they control for quality differences. This provides support for the confounding role of property quality and its correlation with waterfront. On the other hand, if the objective is only to estimate market value and there are omitted variables, then overestimating the impact of water and in turn capturing the impact of some high-quality home amenities may still result in an accurate valuation.

Oceanfront, relative to rivers and lakes, has generally been demonstrated as having more impact on residential property value. One reason, aside from view, may be that, on the west coast of North America at least, there is a dramatic dampening of temperature variation from ocean proximity. This makes summers mild and not too hot in locations like San Diego, from which the data was collected for a 2011 study by Steve Conroy and Jennifer Milosch. The authors included an analysis of general ocean proximity and found that the premium for proximity is nonlinear in distance from the coast. While it may be quite large for homes very close to the coast—possibly increasing the value for homes within 500 feet of the coastline by an estimated 101.9% (compared to all homes beyond six miles of the coast), falling to 62.8% for homes between 500 and 1,000 feet of the coast, and so on—results presented suggest that "the effect declines rapidly (falling to about 21.3% for houses between one and two miles off the coast), and ultimately becomes negligible beyond six miles from the coast." [4]

In 1998, Earl Benson, Julia Hansen, Art Schwartz Jr., and Greg Smersh estimated price premiums for a variety of views and distance from water.[5] For the 1993 sample as a whole, views were found to generate an average 25.6% price premium. However, when views were classified into seven categories, the percentage increase in property value attributable to a view ranged from 8.2% for a poor partial ocean view, 18.1% for a lake view, 29.4% for a good partial ocean view, 30.8% for a superior partial ocean view, and 58.9% for an unobstructed ocean view. Lake frontage property, which provides recreational access as well as view amenities, added 126.7% to value. When property was very close to the ocean, premiums also rose. For example, an unobstructed ocean view adds 68.3% to value if the property is located within 0.1 miles of the ocean, but only 44.7% if the property is located a mile away from the water and 30.6% if located two miles from the water.

Based on prior research described above, it is clear that:

- ✓ Rivers and lakefronts are not as valuable as ocean fronts,
- ✓ Oceanfront sites with waves are highly valued,
- ✓ Larger lakes are better than smaller lakes,
- ✓ The greater the radius of unobstructed views the better,
- ✓ Proximity matters and the waterfront premiums decline rapidly after 60 to 100 meters, and
- ✓ Flood zones on rivers and lakes lower values slightly, but few studies have dealt with elevation risks from sea level rise.

[3] "Estimating the Value of Proximity to Water: When Ceteris Really Is Paribus?" by Jan Rouwendal, Or Levkovich and Ramona van Marwijk, Real Estate Economics, Vol 45:4 Winter, 2017 pp. 829-860.

[4] See Stephen J. Conroy and Jennifer Milosch, "An Estimation of the Coastal Premium for Residential Housing Prices in San Diego County." The Journal of Real Estate Finance and Economics, 42:2, pp. 211–228, 2011.

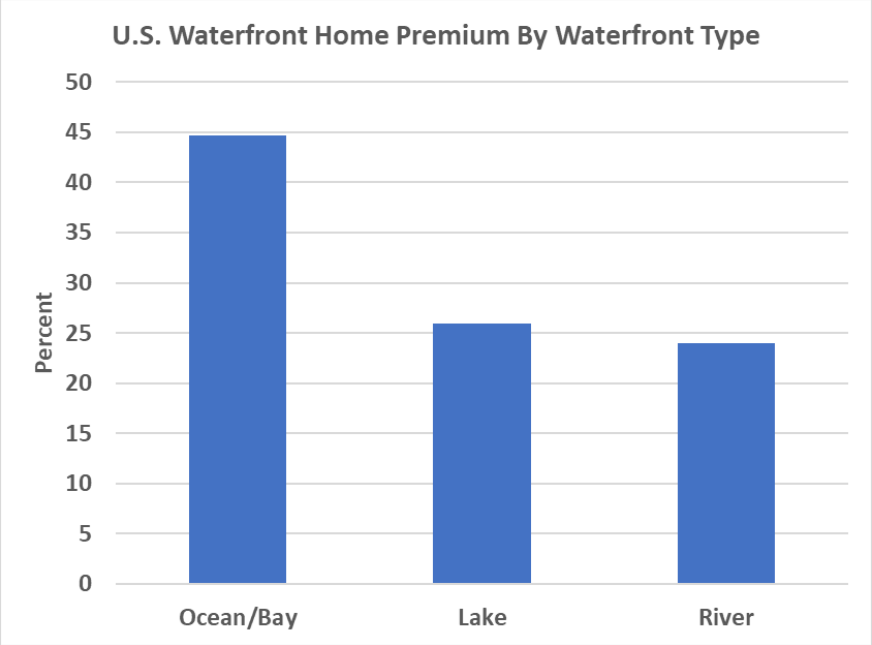
[5] See Benson, Earl D., Hansen, Julia L., Schwartz Jr., Arthur L., Smersh, Greg T. "Pricing Residential Amenities: The Value of a View." Journal of Real Estate Finance and Economics, 16:1, pp. 55–73.

**New Empirical Analysis on Waterfront Valuation Impact**

Here we estimate the net effect of being on a waterfront lot for property sales since the year 2000. We limit the data to a large sample of five-digit zip codes that include both waterfront and off-water sales. These waterfront properties were categorized into three types: ocean and bay front, lakefront, and riverfront. These classifications were based upon a proprietary database which we created to identify and analyze waterfront properties across the entire U.S. using advanced GIS techniques.

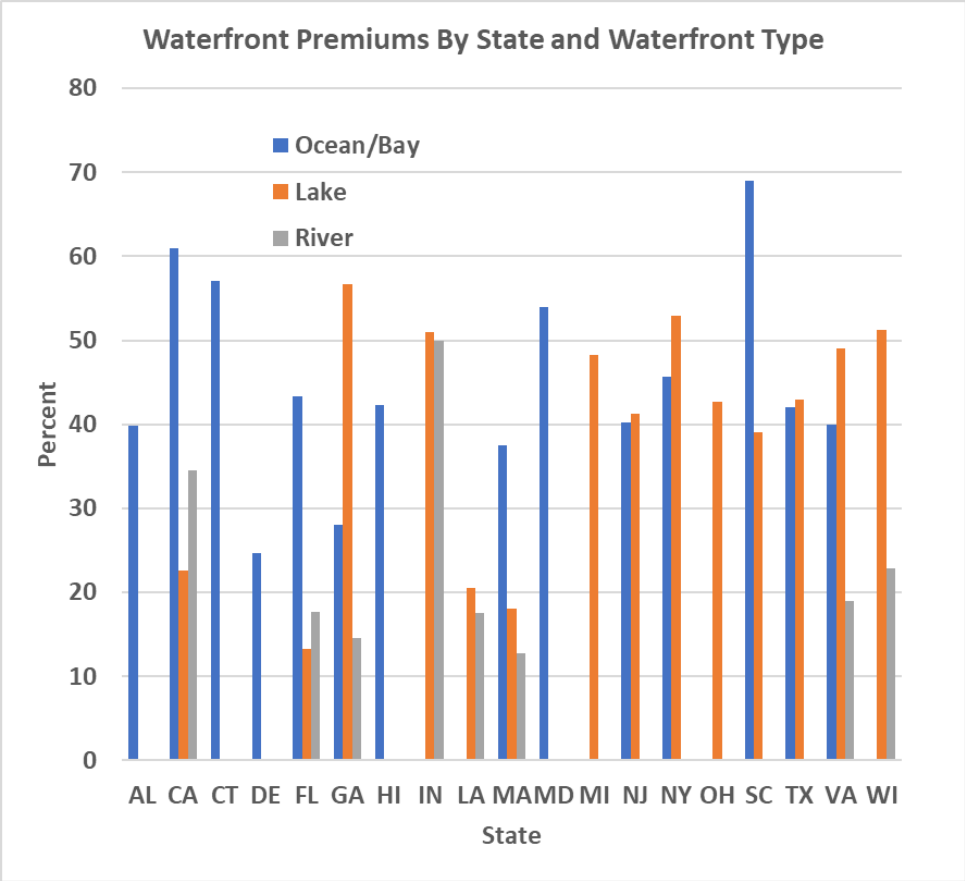
General descriptive results: Rather than show hundreds of regressions, we summarize our results below. Our purpose is to simply confirm the general relationships and then move on to part two of our research, focused more on flood risks. In Exhibit 1 below, we show the overall U.S. average waterfront premiums where we control for physical amenities such as living area, age, etc. and sale year.[6] The results show that oceanfront properties exhibit the highest premiums, nearly 45% over homes within the same zip code but which are off-water, while lakefront homes show premiums of just over 25% and river-front homes 24%. Of course, the quality of amenities may vary so these average premiums are likely to be biased slightly upward, but by less of a differential than previous studies that did not control for as many physical differences or used broader samples. Here we used only observations, several million that were in zip codes adjacent to water. We also find that the premiums vary by location. In Exhibit 2 we show the same descriptive result grouped at the state level of geography.

**Exhibit 1: Waterfront Residential Premiums by Type of Waterfront**




[6] We use a standard hedonic model to control for the influences of physical attributes, including size, age, property condition, and a number of features such as bedrooms, baths, fireplaces, the time of the sale and the general location. We ran hundreds of estimates for zip code level markets and summarize the results here.

**Exhibit 2: Waterfront Residential Premiums by Type of Waterfront by State**




In Exhibit 2 we note some variation in the premiums, but we confirm the general relationship of ocean/bay views compared to lakes and rivers. In Exhibits 3, 4 and 5 below, we dig further and focus on one particular zip code, showing the average differential in residential single-family property transaction prices per square foot of living area for three different zip codes. The first is Newport Beach, oceanfront, with about a 40% premium as of 2016, the second is lakefront property on Canyon Lake, CA, with a premium of about 22% as of 2017, and the third is Stockton, CA, with a premium that has been declining for several years. Stockton is subject to flooding from the San Joaquin River, which has been subject to increasing floods in the last decade.[7] In Exhibits 3, 4 and 5, we see the effects of market cycles and relative premiums that can vary over time. The obvious point is that relative premiums do vary over time, and we should exercise caution when it comes to sweeping generalizations about water proximity and value. It also appears that perceptions and relative value of water proximity might change over time in those areas perceived to be in greater jeopardy of flood risk. This might be what we are observing in Exhibit 5, Stockton, a market subject to increasing concerns about flood risks. The gap from the waterfront to the non-waterfront areas has been shrinking but is still slightly positive.

[7] See, for example, American Rivers, "The San Joaquin Demonstrates the Importance of Floodplain Restoration." Heavy storms and their subsequent flooding in California's San Joaquin basin highlight the importance of multi-benefit floodplain restoration. By Daniel Nylen | February 13, 2017 at https://www.americanrivers.org/2017/02/flooding-san-joaquin-floodplain-restoration/

**Exhibit 3: Sample Oceanfront Historical Premium**

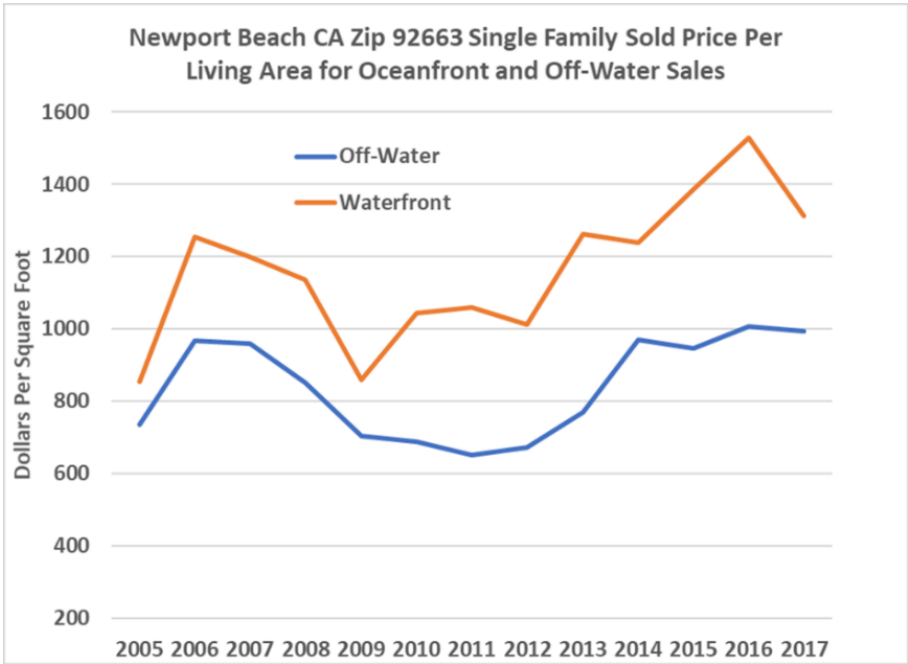



**Exhibit 4: Sample Lakefront Historical Premium**

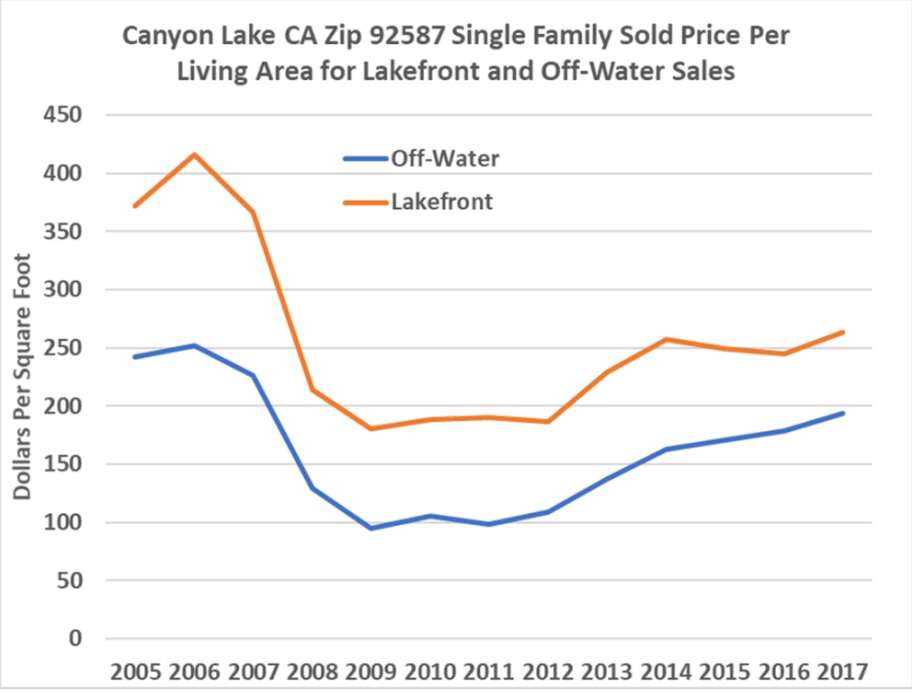
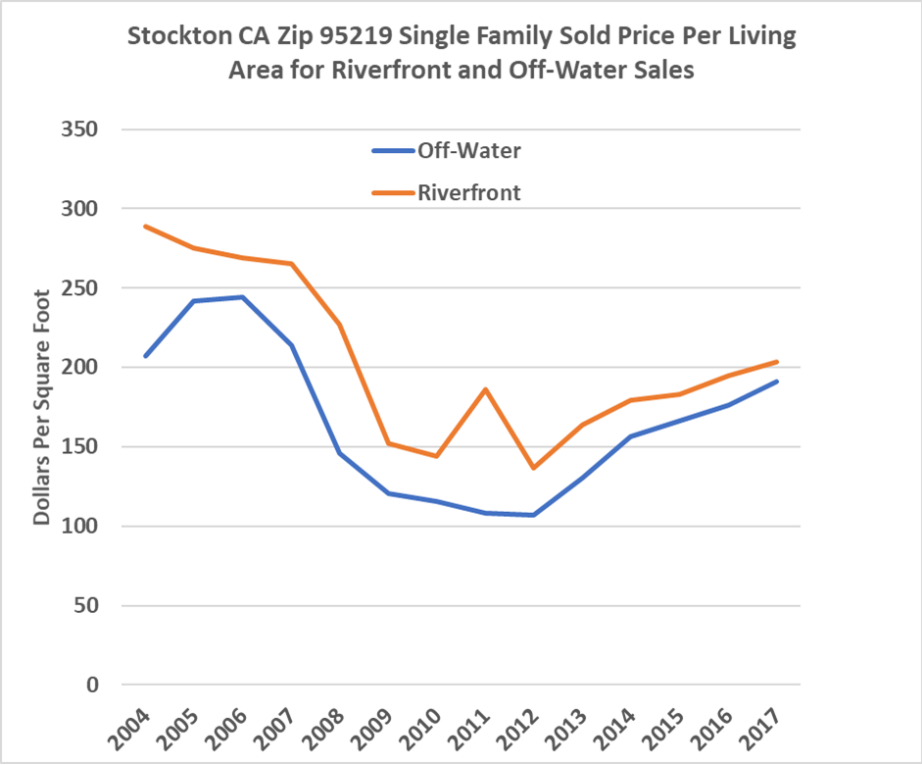


**Exhibit 5: Sample Riverfront Historical Premium**




Here we demonstrate that in most markets throughout the United States, waterfront or near waterfront properties continue to demand significant price premiums, even with the more nascent concerns over flood risks. These premiums on average are highest for oceanfront properties at nearly 45%, followed by lakes and rivers. It is true that the homes near water tend to be higher quality and teasing out the pure water effect is the subject of our ongoing research, but this important finding has already allowed us to improve our valuation models.

**Part 2: Focusing on Flood Risks**

Waterfront sites provide unspoiled views, access to recreation and fishing, and cleaner air. In recent years we have witnessed increased risks from weather-induced floods, especially in low lying geographies. Tests of waterfront premiums for the nation as a whole in the year 2018 indicate that waterfront does have a substantial premium but that it varies by the type of water (ocean, lake or river). We also note that waterfront nearness and impact on value varied by local climate, size and other qualities of the water. Some of the highest premiums are observed on the US west coast based on the temperature-dampening benefits of being near the coast, with such benefits extending several miles inland.

In addition to the positive net premiums observed for waterfront property, there are risks associated with being on the waterfront. The primary risks are flooding and property damage from storms, and in the longer run, from rising sea levels. According to the Intergovernmental Panel on Climate Change (IPCC) monumental report updated in 2018, we have about 12 years left to take actions that could avert devasting impacts from climate change.[8] The report suggests that the world must slash carbon emissions by 45% by 2030 and completely decarbonize by 2050.

[8] See https://www.ipcc.ch

Many countries of the world have taken note, although few are meeting stated goals.[9] The US is not currently among them, having dropped out of the Paris Climate Accord and recently rescinding actions by the EPA that would move the US away from fossil fuels.[10]

Below we examine market reactions from the 2017 hurricanes, Irma and Harvey, and then use elevation data in three metro markets, San Francisco, Chicago and San Diego, to examine the value effects from lying close to sea level.

**Literature on Flood Risks and Property Value**

In 2010 a study was published by authors from the Federal Reserve Bank of Dallas on the impact of hurricanes on housing prices.[11] They examined home prices before and after several major hurricanes over the prior few decades and concluded that there were minor dips in real home prices for a few years, followed by recovery with some minor residual effects when local economic bases were negatively affected. Home prices actually increased more than they decreased a few years after the hurricanes.

In December 2018, 415 investors put out a statement warning that unabated climate change could cause $23 trillion in global economic destruction over the next 80 years, but before that billions in damages from foreclosures on homes that have been destroyed by floods or fires.[12] Also in that same month, a utility company charged with causing wildfires and ignoring climate change (PG&E) in California went bankrupt.[13] Has the market yet capitalized these risks into observable market prices? This is the key question we are exploring.

Several studies since the 2010 study referenced above have now focused on the impact and awareness of being in a location with a high risk of flooding. For example, much of the Sacramento-San Joaquin Delta of California is below sea level, but the area is not considered a floodplain because of the levee system (designed to withstand a 100-year flood). As a result, residents are not informed that they are at risk from floods or purchasing a home in a floodplain.[14] Jessica Ludy and G. Matt Kondolf (2012) studied this region and assessed the residents' awareness

[9] A UNEP report issued by the United Nations in 2018 stated, "All of the science suggests that peaking (carbon emissions) by 2020 is critical," said Kelly Levin, an analyst with the World Resources Institute and one of the report's lead authors. "If you miss that, we rely on much steeper reductions in the future." Moreover, the report finds that the gap between countries' Paris promises and emissions levels that would be needed to stay consistent with the Paris agreement is even larger than previously believed. See https://www.unenvironment.org/resources/emissions-gap-report-2018

[10] See the New York Times report Dec. 19, 2018, by Popovich et al., 78 Environmental Rules on the Way Out Under Trump, at https://www.nytimes.com/interactive/2017/10/05/climate/trump-environment-rules-reversed.html

[11] Anthony Murphy and Eric Strobl, The Impact of Hurricanes on Housing Prices: Evidence from US Coastal Cities." Research Department Working Paper 1009, 2009.

[12] See "Climate Change After wildfires bankrupted a major utility, there's concerns that more severe natural disasters will lead to economic devastation," by Geoff Demicki, Jan. 27, 2019 at https://www.vice.com/en_us/article/59xpxa/the-next-financial-crisis-could-be-caused-by-climate-change

[13] See PG&E files for bankruptcy after California Wildfires, by McLean and Isadore, CNN Business at https://www.cnn.com/2019/01/29/business/pge-bankruptcy-fires/index.html

[14] The National Flood Insurance Program (NFIP) requires owners of property with mortgages within the 100 year flood zones (1 percent chance of flooding) to purchase federal flood insurance. The federal protection against flood risks assists flooded owners in rebuilding homes that have sometimes been flooded before. The cost of the flood insurance is clearly below any market determined rates as evidenced by the increasing losses at the NFIP which is now about $25 billion in debt (Source: Government Accountability Office, NFIP debt). Some beneficiaries of NFIP have flooded many times, as described by this Bloomberg headline:

> "Love of Coastal Living is Draining U.S. Disaster Funds … About 400 miles east of Houston, off the coast of Alabama, Dauphin Island was spared the initial impact of Hurricane Harvey. Yet this tiny sliver of land near the mouth of Mobile Bay is just as important as the battered metropolis to the debate over American disaster policy.

of flood risk. The authors concluded that most residents did not understand the risks of being flooded. Another interpretation of the survey is that households rely on the federal and state governments to restrict development in locations and that these are trusted sources of information on flood risks. If you are allowed to build, the logic implied is that it must not be too dangerous.

A severe flood event may provide information to the market about the risks of flooding and create enough awareness to generate price discounts by changing the characteristics or perceptions of flooding risk of the marginal buyer. Okmyung Bin and Craig E. Landry (2012) studied Pitt County, North Carolina, using multiple storm events within a difference-in-differences framework, and compared flood zone price differentials for a more recent sample of property sales. Prior to Hurricane Fran in 1996, they detected no market risk premium for a home being in a flood zone, but found significant price differentials after major flooding events, amounting to a 5.7% decrease after Hurricane Fran and 8.8% decrease after Hurricane Floyd, but this negative effect on the premium diminished over time, essentially disappearing about five or six years after each event. They concluded the lack of a persistent effect suggests that buyers' and sellers' risk perceptions may change with the prevalence of hazard events and that homebuyers seem unaware of flood risks and insurance requirements.

Jesse M. Keenan has suggested in several studies (2017, 2018) that within Florida, "to be on the beach costs a lot more money, and the cheaper parts of town were furthest from the beach – but it just turns out that the cheapest parts of town furthest from the beach are the highest elevation, and now they're worth a lot more than they used to be."[15] Keenan suggests that eventually, residents will move to higher ground, an effect he calls "Climate Gentrification," but when is part of the motivation for this and other studies.

Francesc Ortega and Suleyman Taspinar (2018) examined the effects of Hurricane Sandy on property values. They assembled a large plot-level dataset with rich geographic data on housing sales in New York City for the period 2003-2015, along with information on which building structures were damaged by Hurricane Sandy and to what degree. The average negative impact was approximately 13%. These effects were also found for houses that were not damaged but are now perceived to be at high risk of coastal flooding. The reductions in value could, as the authors note, alternatively have been caused by increases in flood insurance premiums. Insurance premiums, in effect, make flood risks real. However, it is often the case that households in locations with chances of flooding do not purchase flood insurance. For example, in the poorest areas of Texas, hit by Hurricane Harvey in the summer of 2017, few residents had flood insurance.

> "I wish I had flood insurance now," lamented Leroy Moore, a 58-year-old whose home in Northeast Houston filled with water. He cancelled his flood policy when it grew too expensive. He and his wife were rescued from the rising waters on Sunday by National Guard troops and are now sleeping

That's because the 14-mile-long island, home to only about 1,300 people, floods again and again, hurricane or no hurricane. Again and again, those homes are repaired and rebuilt, largely at the expense of U.S. taxpayers. The homes on Dauphin Island are among the five million that are covered by the National Flood Insurance Program. Founded in 1968 to make sure homeowners in flood-prone areas could get affordable insurance, the program ends up paying most residential flood insurance claims in the U.S. Partly as a result, development along coasts and riverbanks and in flood plains has exploded over the past 50 years." Source: Bloomberg BusinessWeek, August 31, 2017, story by Christopher Flavelle)

[15] Scientific American interview, August 14, 2017.

in a church. “When it's a choice to make between things and life, sometimes you've just got to let the things go and hang on to life.”[16]

Regular home insurance covers wind damage but not flooding. Only 17 percent of homeowners in the eight counties most directly affected by Harvey had flood insurance, according to a Washington Post analysis of Federal Emergency Management Agency (FEMA) data. While homeowners with a mortgage are required to purchase separate flood insurance policies, the cost of the insurance may be prohibitive for low income families. For example, in Texas, the average cost for a NFIP (National Flood Insurance Program) plan is $500 a year, but it can rise to more than $2,000 for homes inside a floodplain.[17]

Bernstein, Gustafson and Lewis (2017) have run the most exhaustive study to date on the potential effects of sea level rise.[18] They use data from NOAA to map all the U.S. coasts for sea level rise risks. They conclude that current sophisticated buyers are becoming concerned about sea level rise and are discounting low-lying properties by approximately 7% compared to similar equal distant but less exposed properties. They further break affected properties into exposure buckets, with properties that will experience ocean encroachment after one foot of global average sea level rise trading at a 22% discount, two to three feet at a 17% discount, four to five feet at a 9% discount and six feet at a 6% discount. They find no rental discounts and this makes sense given the shorter-term horizon and lower wealth exposure of renters.

The primary challenge for any estimate of the cost (capitalization of flooding risk into the value of the property) of flooding is to remove unobserved selection or sorting by type of owners, property quality, or neighborhood quality that is correlated with the risk of partial or catastrophic flooding. Unobserved factors could bias the coefficient estimate up or down. For example, consider two buildings next to each other (same view and location qualities) in the same neighborhood on the waterfront. One building is 15 feet above current sea levels and the second neighboring building is one foot above sea level. The original buildings were constructed and sold in the 1970s in the same year and are otherwise identical. The building on the 15 foot above sea level lot has had interior renovations multiple times and the building on the one-foot lot has never been updated to current standards because of a fear of flooding. As a result, the building on the one-foot lot is much lower in quality. When this lower quality property sells the econometrician will find a large discount for the one-foot elevation building. This “flooding discount” will reflect the role of the elevation (flooding risk) and the unobserved building quality deterioration. As a result, the capitalization of the flooding risk will be overestimated. Therefore, any estimate of waterfront premiums must control for the quality of the building, the attributes of the building, and the attributes of the location. Bernstein, Gustafson and Lewis (2017) approached this problem by using extensive location controls, but with only a few attributes of the building (number of bedrooms, square feet and age of the building) and no measures of quality. Here we will use a physical condition measure in addition to the typical physical attributes.

Bélanger, Bourdeau-Brien and Dumestre analyzed the impact of flood zones on residential property prices in Canada. The methodology includes analyzing for-sale asking prices. When available, the authors also factor in property characteristics (type of building, building age, number of bedrooms/bathrooms and living areas, quality

[16] “Where Harvey is hitting hardest, 80 percent lack flood insurance” by Heather Long, August 29, 2017, The Washington Post

[17] Ibid.

[18] See Asaf Bernstein, Matthew Gustafson, and Ryan Lewis, “Disaster on the Horizon: The Price Effect of Seal Level Rise” SRN-id3073842 working paper.

of construction materials, among other elements). Results suggest that homes located on a high-risk floodplain are subject to a 4.1% loss in value.

Additionally, the second through fourth volumes of the US National Climate Assessment, released in November 2018, project between $66 and $106 billion dollars in losses directly related to flooding by 2050 and between $238 and $507 billion by 2100. These results have a direct impact on the economy, with the report predicting a 10% decrease in GDP from climate change by 2100. The assessment suggests that actions being taken by cities, from installing pumps to preserving wetlands, are not expected to be nearly enough to counteract the potential impacts of climate change and that stronger, unprecedented action needs to be taken within the next 12 years.[19]

A study by Pilla, Gharbia and Lyons shows slightly different results from those discussed above. The study uses hedonic regression techniques to analyze the relationship between flood risk and residential sales and rental listings in Dublin, Ireland. The authors claim that the results are mixed, since "flood events are found to have a negative impact, particularly on sale prices, while being at 1% risk has no effect once past flood events are controlled for. For past flood events, however, there is evidence to suggest that this impacts on property values, certainly in the areas affected and up to 200 meters away." According to the authors, one of the key findings of this paper is that perceptions of flood risk are related to memory and are therefore more adaptive (learning from the past) than rational (based on scientific data). They conclude that "households pay more attention to past flood events than to scientific assessments of flood risk, [which] has important policy implications about communicating flood risk to consumers."

In a study by Atreya and Czajkowski, the authors analyze positive amenities associated with water proximity by using spatial analysis, and interact distance to the nearest coastline with housing sale prices for the specific region of Galveston County, Texas.[20] They add an additional layer of analysis to account for differences in identified flood risk return periods. Results show that "properties located in the high-risk flood areas command a price premium compared to those located outside." In two of the high-risk areas analyzed the price premium is up to 146%. They conclude that, "notably, even with [their] systematic interaction approach coupled with more detailed flood risk return period data, [they] find that in the absence of a major flood event it is difficult for the negative flood amenity value based upon the objective flood risk to sufficiently counteract a homeowner's strong desire to live near the water." Our results below are not that different from those found here.

**Empirical Home Price Trends After a Flood Event: Results from Harvey and Irma from 2017 and Katrina in 2005**

As it relates to the United States, Hurricane Florence hit North Carolina in September 2018, but there is not enough history to track any home price trends. We do, however, have some history for Harvey and Irma from 2017 and Katrina in 2005.

Category 4 Hurricane Harvey hit Texas August 25, 2017. Rockport, Texas got hit head-on and Houston also received a fair amount of damage. Harvey caused $125 billion in property damage in Texas according to the National Hurricane Center. Significant federal relief, also in the range of $125 billion, was provided soon after the storm.[21] Approximately 204,000 homes were damaged and 738,000 people asked for help from the federal government.

[19] See NCA4 Vol II: Impacts, Risks, and Adaptation in the United States, at https://www.globalchange.gov/nca4

[20] See "Housing Price Response to the Interaction of Positive Coastal Amenities and Negative Flood Risks" by Ajita Atreya and Jeffrey Czajkowski (2014) at https://ageconsearch.umn.edu/record/180098/files/Atreya_Czajkowski_Updated_AAEA2014.pdf

[21] See https://www.thebalance.com/hurricane-harvey-facts-damage-costs-4150087

Irma was also a category 4 hurricane and she hit Florida August 30, 2017, costing some $70 billion in property damage, along with significant dampening of tourist visitors for the following few months,[22] although tourist demand was back to normal one year later. Among those markets hit hardest was Key West, where there was no place to escape, aside from leaving the island entirely and heading north before the storm arrived.[23]

Harvey hit Texas in late August, and we see the volume of sales dropped to nearly zero in September, perhaps with some sales delayed. This is typical after a major natural disaster. Vacancy rates drop and potential sellers dwindle as everyone reassesses the market. The few transactions that do occur do so within the context of a lessened supply, while many residents seek temporary shelter. Sales volume in Texas after Harvey remained below normal for several months but has since rebounded, as seen in Exhibit 6. In Exhibit 7, we see that prices dipped more than seasonally normal in early 2018, both on a sales price basis and on a price per square foot basis. While prices remain a little lower than before Harvey, they have rebounded, perhaps influenced by insurance rebuilding and funds brought into the market. There appears to be little permanent impact and it is surprising how resilient the market is.

Irma, also hitting Key West in late August, resulted in few sales in September 2017, as shown in Exhibit 8; however, sales volume returned to nearly normal fairly quickly. Overall sales prices dipped in September, but for very few sales, and have rebounded since, although the price per square foot seems to be running just a little lower than before, as seen in Exhibit 9. These comparisons are not from markets deep enough to offset variations in the quality and features included in the mix of sales, so any conclusions are questionable. It does seem, though, that because of insurance and a general optimism on the part of some buyers, little permanent fears or price effects remain in these two markets hit head-on by major storms. Other markets that were examined included the coastal zip codes of Marco Island, Naples, and Jacksonville, all areas hit hard by Irma according to news reports, but almost no market reaction can be detected aside from a very temporary dip.

[22] See https://www.usatoday.com/story/travel/2018/09/07/florida-welcomes-travelers-one-year-after-hurricane-irma/1220408002/
[23] Ibid.

Exhibit 6: Rockport, TX Sales Volume Over Time

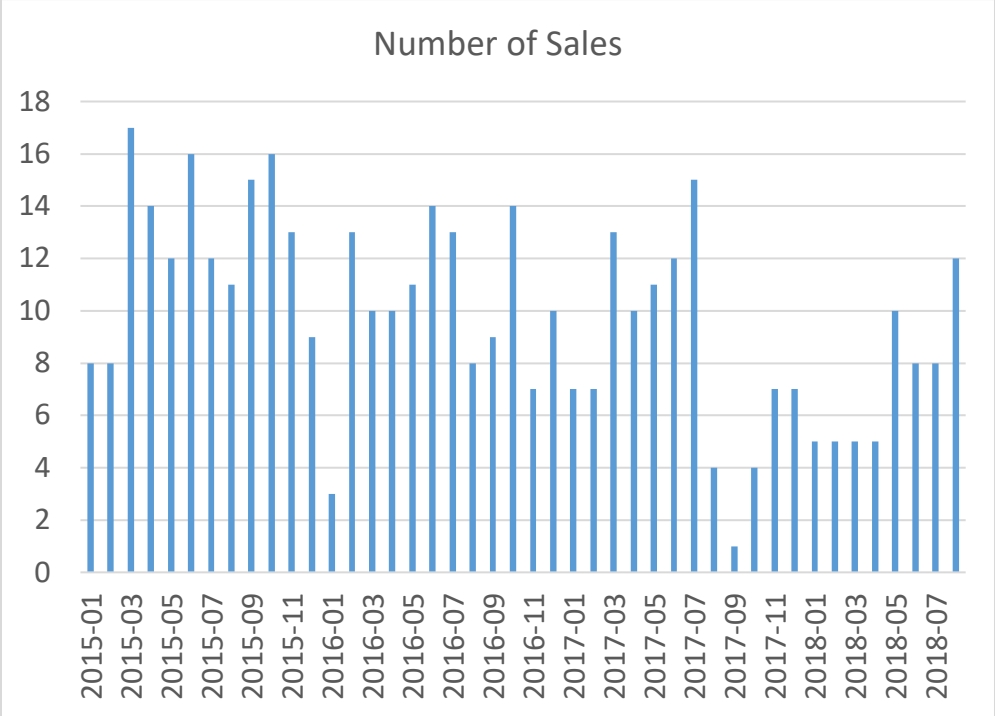



Exhibit 7: Rockport, TX Sales Prices and Sales Price Per Square Foot Over Time

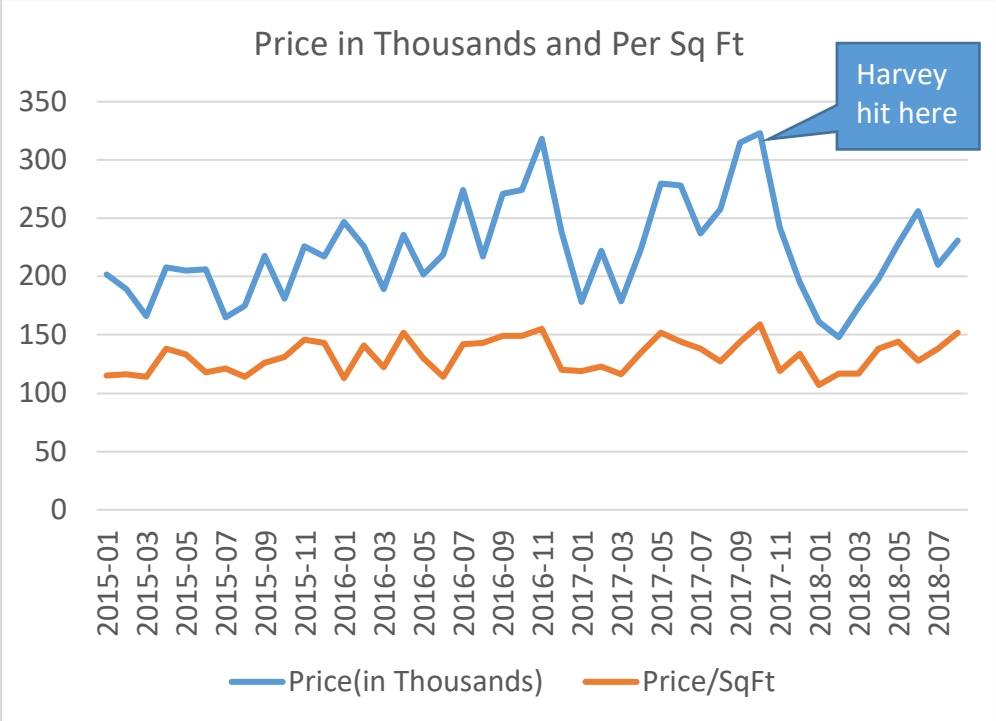


Exhibit 8: Key West, FL Sales Volume Over Time

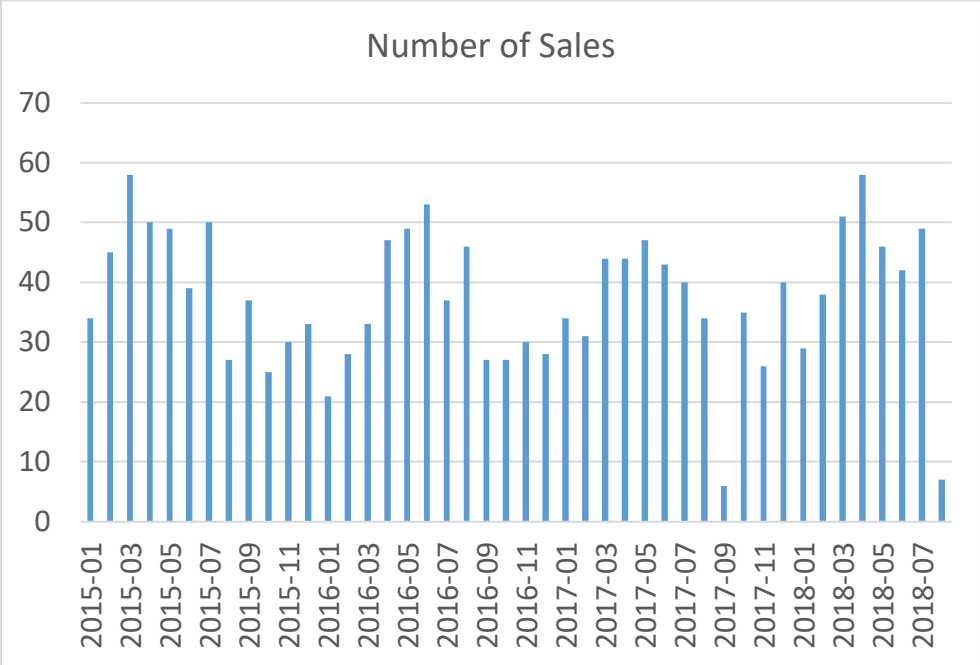
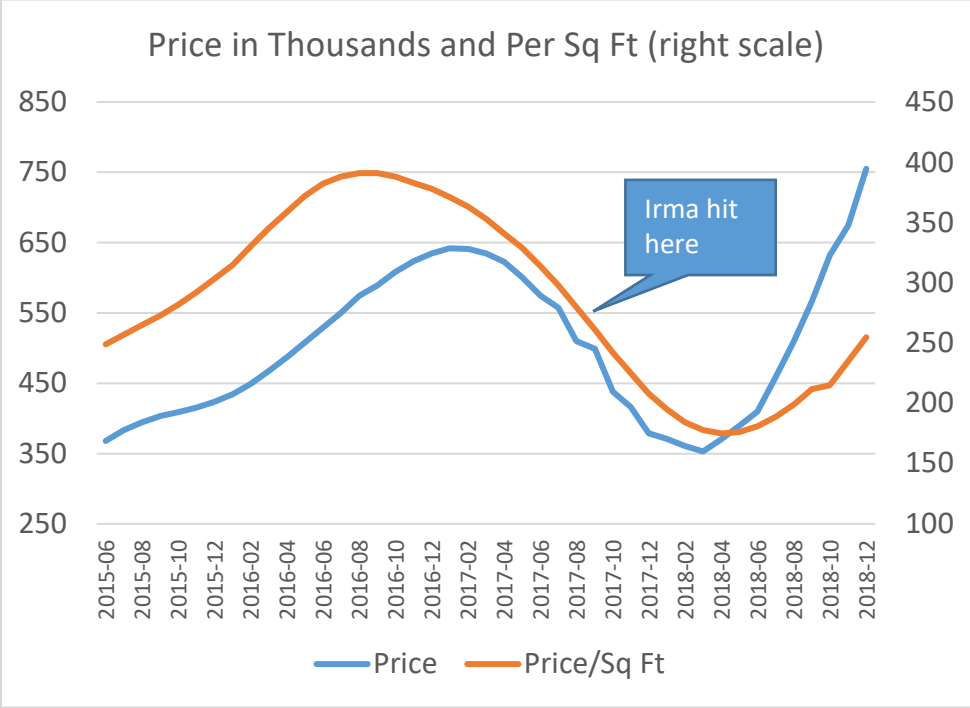


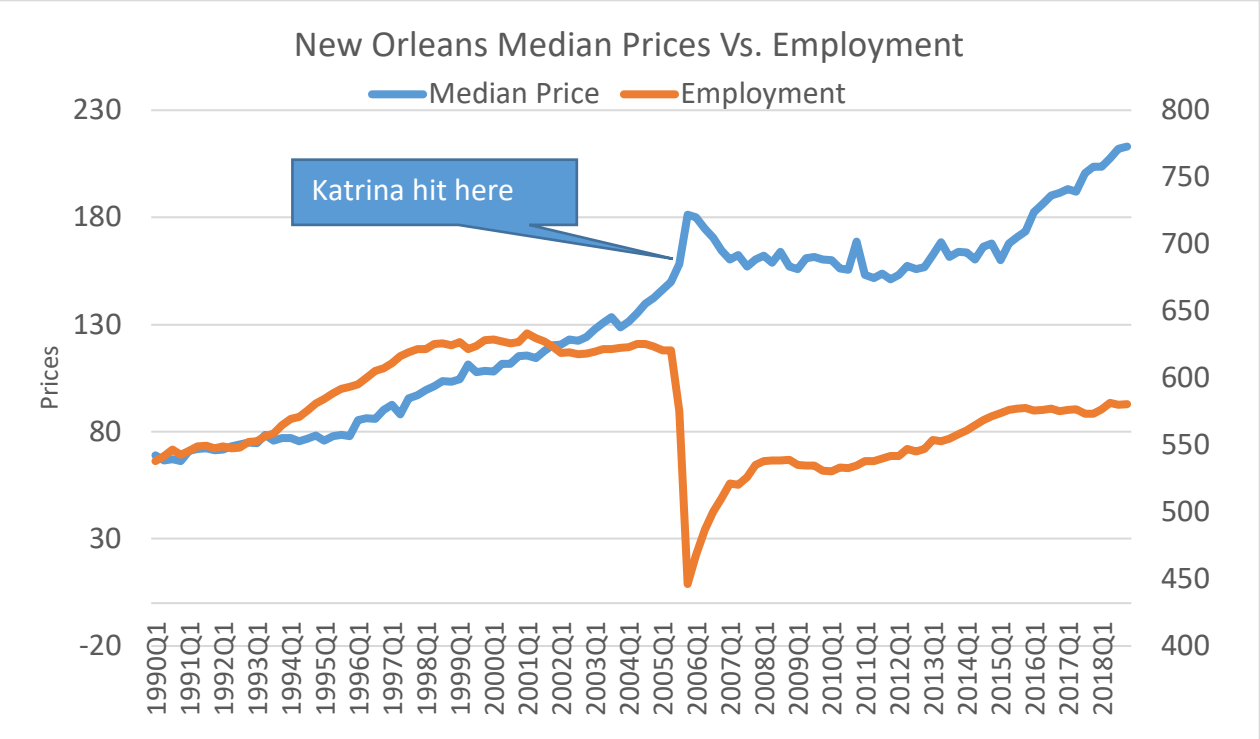

Exhibit 9: Key West Sales Prices and Sales Price Per Square Foot Over Time



Investors reaped the benefits of short-term distress from Harvey, and possibly many other such storms.[24] Brian Spitz, a local investor and president of Big State Home Buyers, who has bought thousands of homes over the years, suggests that investors know how the system of federal support and insurance works. Hurricane Harvey was the most destructive storm in Houston's history. The late-August storm dumped up to 60 inches of rain on southeast Texas, but the resulting damage was multiplied by actions taken – and not taken – during the past 50 years. The national flood insurance program encourages homeowners to build, be flooded and rebuild according to David Hunn.[25] What these investors may also know is the cost to repair homes and how fast a well insured or protected market will rebound.

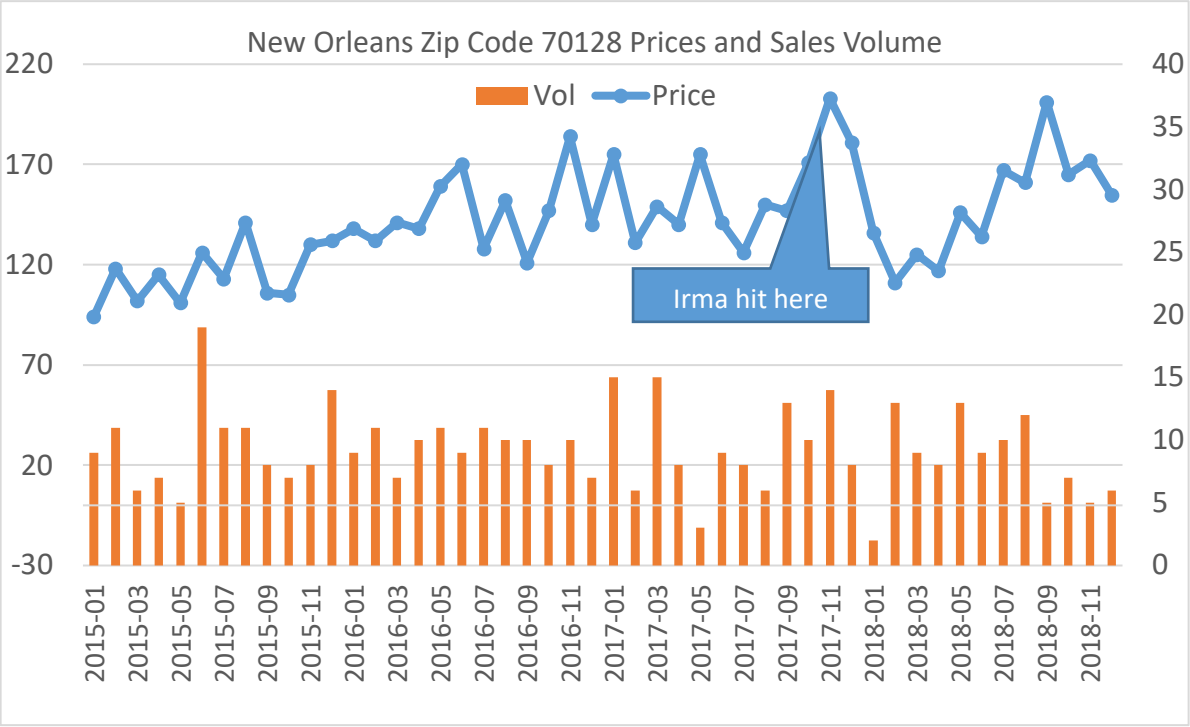
Several other markets have been examined, aside from those shown above. One area of the US where many of the residents live at or below sea level is New Orleans. In Exhibit 10 below, we examine prices and employment in New Orleans from 1990 through 2018. New Orleans was hit hard by Hurricane Katrina, which landed August 29, 2005. A total of 1,577 fatalities occurred in Louisiana, directly as a result of Katrina, by far the most of any region. Insurance companies paid out an estimated $41 billion in claims, mostly in Louisiana with $16.3 billion of that from the National Flood Insurance Program.[26] Over a quarter of a million residents were displaced and many could not return to their jobs for months. The employment losses seem to be the most dominant reason for the slow recovery in home prices after 2006. Still, home prices did rebound, after a short-term spike up followed by a quick decline.

Exhibit 10: New Orleans Home Prices from 1990 Through 2018




New Orleans has several coastal markets that are actually below sea level. Zip code 70128 is about a foot below sea level and it was flooded during Irma in 2017. We do see the typical short-term reaction from floods but soon prices rebound as shown in Exhibit 11, just as in all the other markets examined.

Exhibit 11: New Orleans Home Prices Vs. Sales Volume During Irma




**Data for a More Rigorous Elevation Test In San Francisco, Chicago and San Diego Metros**

Separating the positive from the negative: We attempt to disentangle the discount associated with being at risk of flooding and sea level rises from the positive amenity of having a waterfront lot in a larger market. The data here includes three metro areas with 10,720 residential single-family home observations in zip codes touching waterfront from the San Francisco metro area, where data on elevation and nearness to water was available, along with the variables required to control for other influences on value. For San Diego there are 91,166 observations and for Chicago, 90,157.

Again, the entire sample is selected only from zip codes touching the waterfront, including the inland bay. These sales occurred from January 2012 through the end of third quarter 2017, with dummy variables used for each quarter over that time span. This time we define waterfront more broadly as within 100 meters of the average high-tide water line. This results in more sites being defined as waterfront and lowers the expected premium compared to being immediately adjacent to waterfront when compared to nearby homes.

Our model in general is

$$\ln p = \alpha z + \alpha t + \ln(\beta X_1 + \beta X_2 + \beta X_n + \beta W + \beta E_1 + \beta E_2 + \beta E_3) + \varepsilon$$

[24] See "Listen: How a Houston investor buys and sells flooded homes" by Nancy Sarnoff, Jan.29, 2018, Houston Chronicle.
[25] Ibid.
[26] See https://www.cnn.com/2013/08/23/us/hurricane-katrina-statistics-fast-facts/index.html

Independent variables are described below. Here p is the selling price, α is an intercept term, αt controls for time as a dummy, and the X variables include living area, lot size, swimming pool, bedrooms, baths, age, age squared, garage units, condition of property using six group dummies, and then waterfront dummies, W, for being a parcel touching the high tide mark, E, elevation at 1 = 1 meter or less, 2 = 2 meters of less and 3 = 3 meters or less. Variables included were significant at the 10% level or better.

Our model results for these three markets are summarized below. The waterfront premiums shown here are only for property actually touching the high tide watermark, and the control sample includes all properties within the same zip code but not touching the waterfront. The elevation premiums are in addition to the waterfront premium. There were 90,157 observations for Chicago, 91,166 observations for San Diego and 10,720 observations for San Francisco. These large samples allow us to rely upon the models, even though there was still a fair amount of noise in the data from unobserved variables.

Exhibit 12: Table of Panel Regression Results Summary of Elevation Coefficients

| Metro Mkt | Waterfront | Elevation | Elevation | Elevation | Adj R Sq | F-Value |
|---|---|---|---|---|---|---|
| | Touching | 1 meter | 2 meters | 3 meters | | |
| Chicago | 31.98% | 5.38% | 5.35% | 5.69% | .669 | 11.56 |
| Sand Diego | 35.33% | 11.66%* | 13.53% | 26.57% | .655 | 13.78 |
| San Fran | 8.65% | -4.86%* | -13.97%* | 4.30% | .718 | 14.11 |

* Significant at the 10% level. No other elevation coefficients were significant at the 10% or higher.

**Results for Chicago, San Diego and San Francisco At Various Elevations**

With the exception of the San Francisco metro area, we do not find a negative premium for low elevations near the waterfront compared to near water higher elevation property. In fact, the Chicago lake low elevation results suggest few fears from flood risks. In San Diego, where like San Francisco, the risks are again ocean-based, no flood risk premiums are observed, even at the lowest levels where high tides have started to flood the closest homes a few times a year. Most of the regression coefficients on elevation are not statistically significant, whether tested together or alone. These results could reflect a historical lack of hurricanes on the west coast of the US, and a lack of concern for sea level rise despite the fact that San Diego already experiences modest floods during high tides.[27]

For San Francisco, using only single-family residential homes we find near waterfront premiums for those homes adjacent to water compared to those not adjacent to waterfront, but still within the same zip code. By using only homes in the same zip code, we probably account for some of the quality bias, that is, most neighborhoods near water are already expensive high-quality homes, although our control model fit is fairly good.

It is entirely possible that flood risks from hurricanes are reflected in Florida markets, although our general empirical results do not support that conclusion when examined a year or so after a major storm event, nor did the study by Murphy and Strobl focused on hurricanes. On the west coast of the US and in the Great Lakes region of Chicago, no elevation discount fear is apparent.

[27] The neighborhoods of Pacific Beach, Ocean Beach and parts of Del Mar have already flooded several times during high tides with moderate storms. However, these neighborhoods have a large proportion of short-term rentals and the rental income has not changed significantly as a result of these occasional floods.

Exhibit 13 shows elevation data for the continental United States, Mexico, Southern Canada and part of the Caribbean and Central America. This map is hard to see so a few close-ups are shown in the appendix. Most of the flood-prone zones are in FL, the Southeast region of TX and LA. The west coast of the US is fairly steep but there are some extensive low-lying inland areas just east and south of San Francisco. Exhibit 14 shows a detailed map of elevation data for San Francisco. The pink and yellow areas (or lighter shades) are at high risk of flooding from weather storms and high tides. These should be the areas where flood risk discounts will appear, but we cannot confirm a long-term impact from climate change and weather-induced flood risks.

Exhibit 13: Elevation data for the US, Mexico, the Caribbean and Southern Canada

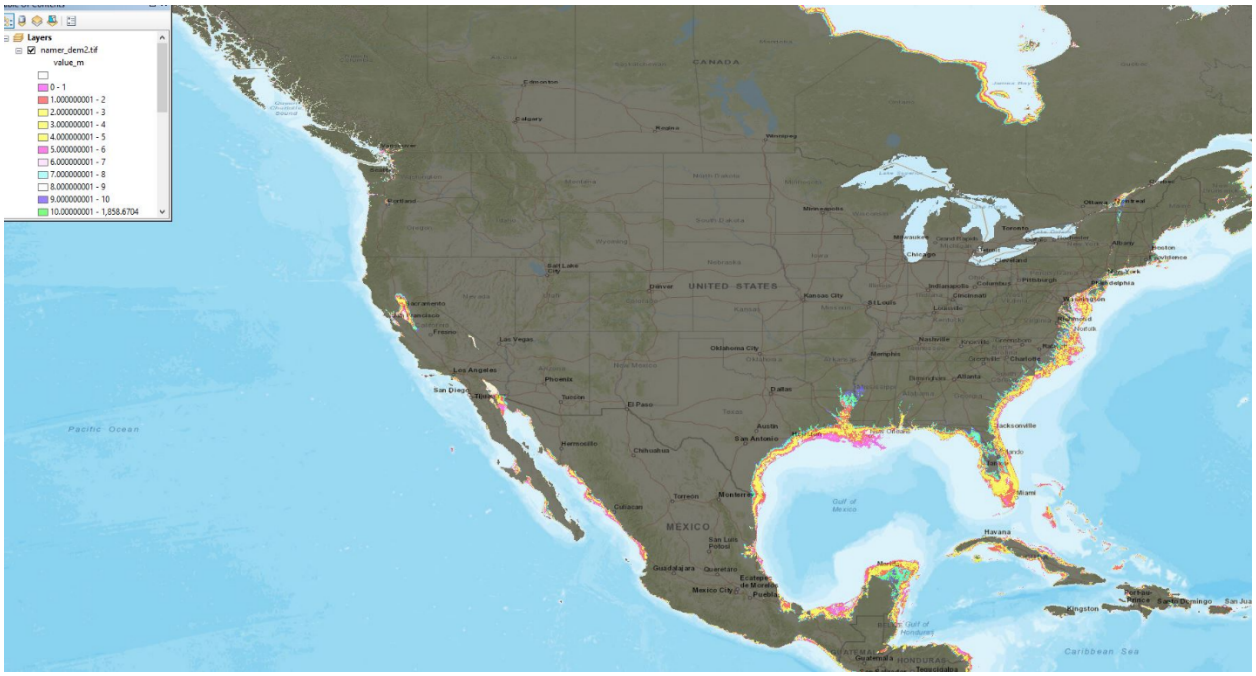
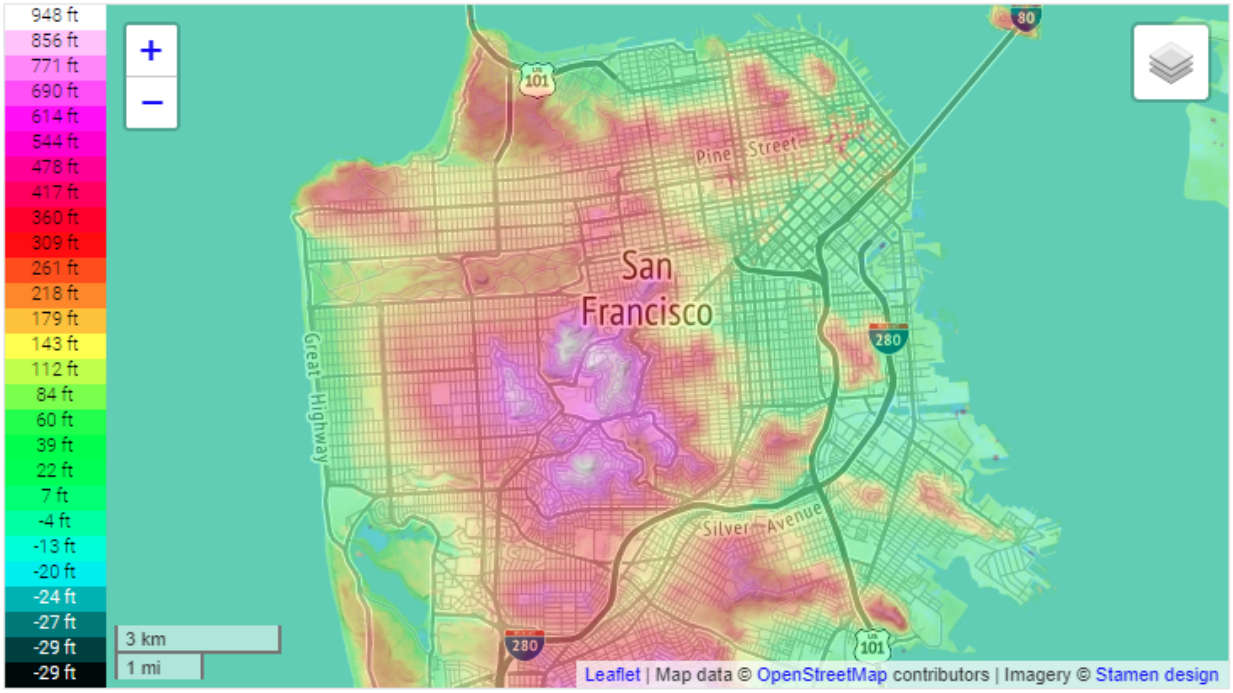



Exhibit 14: Elevations in San Francisco




The results in San Francisco make intuitive sense, but the results in San Diego and Chicago do not, unless the elevation data does not really reflect flood risks based on sea walls or other infrastructure not considered in the elevation measure. Access to waterfront should have a positive influence on price, even compared to properties in the same zip code, but those in low elevations, subject to flood risks, should exhibit an offsetting negative impact on value when controlling for property attributes as we did here. The San Francisco results are similar to Bernstein, Gustafson and Lewis (2017) for the one and two-meter effects, but our San Diego and Chicago results are not.[28]

A recent paper by Baylis and Boomhower might provide an explanation.[29] In a study on wildfire risks they conclude that a substantial portion of the total social costs of wildfires comes, historically, from federal firefighting efforts that prevent or reduce loss. This taxpayer-supported cost, in turn, results in higher property values for those properties most at risk relative to their values if the high-risk properties had to support the full costs of protection. We see the same type of moral hazard for owners of coastal properties at risk of flooding. Not only are the flood maps significantly out of date, where properties within designated flood zones are required to buy flood insurance, but the government through FEMA[30] and NFIP[31] has subsidized owners within flood zones, whether designated as such or not.

A final theory for the lack of a significant price effect from flood risks, such as that in Florida from hurricanes, is that the more typical buyers of coastal property are older and wealthy enough not to care. That is, for someone

[28] See Asaf Bernstein, Matthew Gustafson, and Ryan Lewis, "Disaster on the Horizon: The Price Effect of Seal Level Rise" SRN-id3073842 working paper.
[29] See Patrick Baylis and Judson Boomhower, "Moral Hazard, and the Economic Influence of Natural Disasters," Dec. 26, 2018. Vancouver School of Economics, University of British Columbia working paper.
[30] Federal Emergency Management Agency.
[31] National Flood Insurance Program.

in their 70's or 80's, who cares about 2100 anyway or even 2050? A spot check of some demographics does confirm the significantly higher average age for buyers along the east coast of Florida.[32]

**Conclusions**

The market should, in theory, recognize and discount property value in line with flood risks along the coasts. Results here bear out some possible but inconsistent evidence of housing market price discounts in higher risk, more flood-prone locations, not subject to recent storms. However, in markets hit hard by storms, price discounts seem to dissipate quickly and either the new wave of buyers ignores or forgets the risks, or alternatively insurance proceeds mitigate the value impact. When employment displacement lingers, home prices are also slower to recover, as in the case of New Orleans after Katrina in 2005.

The federal flood insurance programs have clearly been underpriced based on the huge deficit accumulating over the past several years, and this has resulted in artificially propping up housing markets in flood zones, correctly identified in some cases but often not, by outdated maps.[33] There exists a significant moral hazard from such subsidies that has resulted in minor if any capitalization of flood risks into property values.

Claims of significant losses of property value are based upon actual losses at the time of the storm, and not based on property values after insurance proceeds or other FEMA subsidies. For example, CBS News reported on February 27, 2019 that homes lost $15.8 billion from sea level rise in the prior few years, but this was based upon damage losses, not property values after repairs and rebuilding.[34] From 1993 through 2017 sea levels rose by three inches, only an eighth of an inch per year. Perhaps this is too slow to expect a human market reaction where an entire lifetime might witness only a 10-inch rise? Of course, this rate of sea level rise will accelerate and the high tides and storms will cause increasingly more damage more frequently. At some point the market will see this as imminent enough to warrant concern and avoid flood-prone areas, but not fully, if such risks are mitigated by tax payer subsidies.

This analysis is important, not just to become better at valuing residential properties within waterfront proximity, but rather because the massive amount of infrastructure construction necessary to mitigate billions of dollars of property damage and economic disruptions requires a better understanding of what is at risk. While there is no question about the potential for catastrophic property damage and the possibility of mass population relocation required with climate change and more frequent major storms, we cannot yet verify that the existing insurance policies or society as a whole has its eyes wide open to these risks or subsidies.

[32] Using ESRI data the percentage of those aged 65 and above was significantly higher on the South East Florida coast than the nation as a whole for data from 2017.

[33] The deficit of outflows over insurance premiums has resulted in a $25 billion deficit as of September 2017. See Why Federal Flood Program is Sinking Deeper into Debt: CBO Report: in the Insurance Journal, September 5, 2017, at https://www.insurancejournal.com/news/national/2017/09/05/463227.htm

[34] See https://www.cbsnews.com/news/homes-lose-15-8-billion-in-value-as-seas-rise-maine-to-mississippi/?ftag=CNM-00-10aac3a

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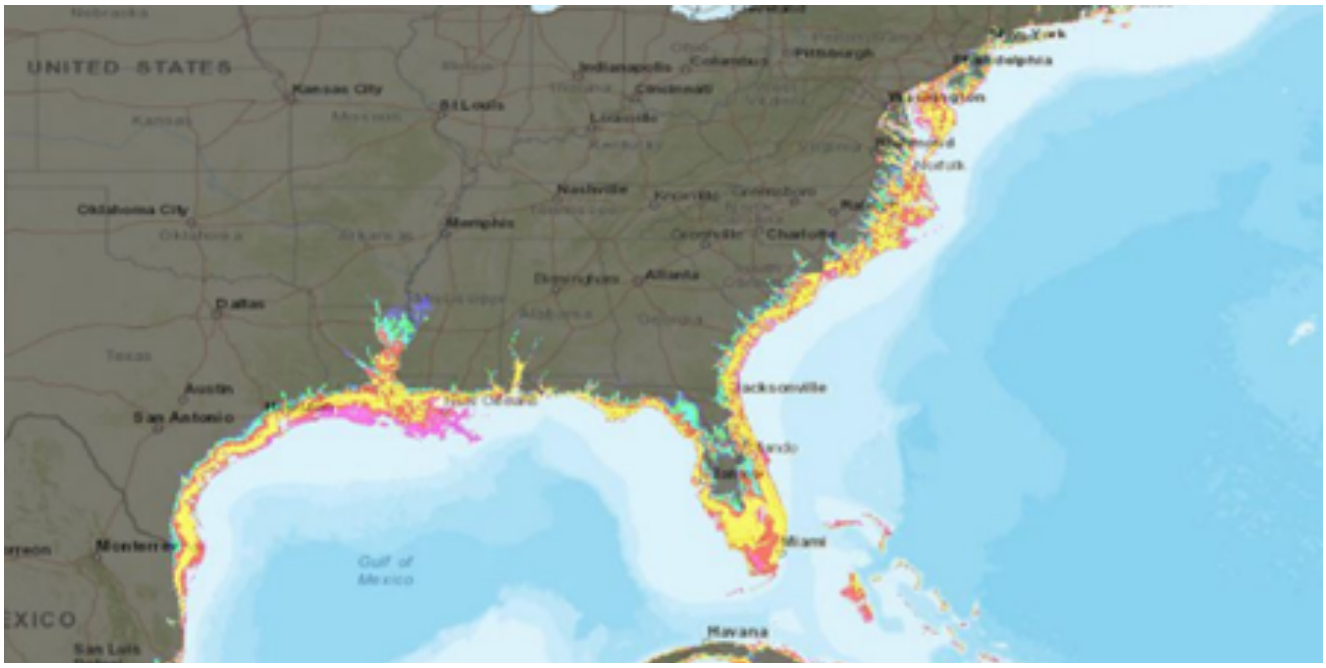
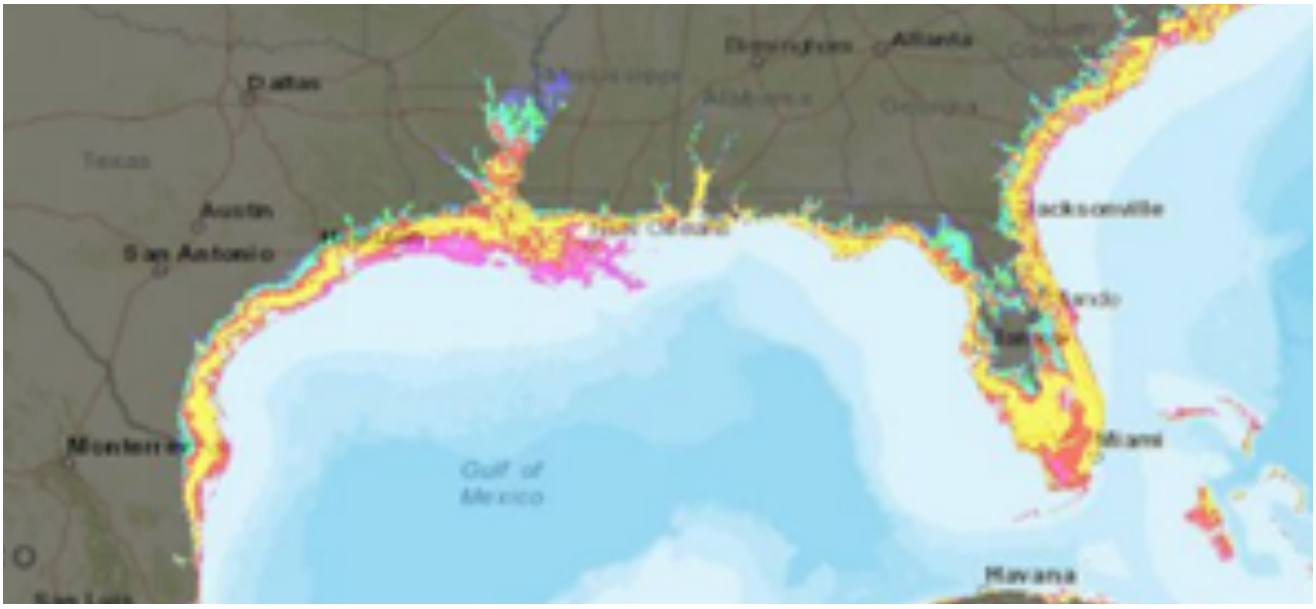
Appendix: Some close-up US maps showing elevations with yellow and pink as likely to be underwater by 2100.

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