

# Sea Level Rise and Its Impact on California Housing Markets

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## Summary

- The impact of sea level rise (SLR) on coastal California housing markets are estimated as follows:
  - Number of homes affected -- 1 foot: 10,900, 2 feet: 19,000, 4 feet: 66,600
  - Number of people affected -- 1 foot: 27,000, 2 feet: 46,000, 4 feet: 155,600
  - Property value loss -- 1 foot: \$11 billion, 2 feet: \$20 billion, 4 feet: \$68 billion
  - Coastal California zip codes are divided into three zones by the percentage of housing units impacted by SLR of 4 feet: Green Zone (0%, 196 zip codes), Yellow Zone (below 4%, 81 zip codes), and Red Zone (above 4%, 30 zip codes).
  - We do not find evidence that homebuyers have seriously factored SLR risk into their investment decisions in California. Red Zone houses are still in high demand by high-income and high-education households.
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The latest report from the United Nations' Intergovernmental Panel on Climate Change (IPCC) predicts that global mean sea levels will mostly likely rise between 0.95 feet and 3.6 feet by the end of the century.<sup>1</sup> Their forecasted range of sea level rise (SLR) is based on two assumptions from Representative Concentration Pathways (RCP):

- 1) Low scenario (RCP2.6) represents a low greenhouse gas emissions and high mitigation future with projected global mean surface temperature increased by 1.6 degrees Celsius by 2100, causing SLR of 0.95 feet;
- 2) High scenario (RCP8.5) represents high greenhouse gas emissions in the absence of policies to combat climate change leading to a temperature increase of 4.3 degrees Celsius by 2100, causing SLR of 3.6 feet.<sup>2</sup>

Based on IPCC's forecasts and assumptions, this report will analyze how and where SLR would impact California coastal housing markets.

## The Direct Impact on California Housing Markets

To measure how many houses would be affected and where they would be exposed to SLR, we use the data from the Union of Concerned Scientists (UCS)<sup>3</sup> based on Zillow Transaction and Assessment Dataset (ZTRAX). They provide data to project how many homes and people will be at risk of chronic inundation due to SLR by zip code in the U.S. by the year 2100. Figure 1 shows the number of people and homes in California and Figure 2 shows their estimated

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1. See IPCC's *Special Report on the Ocean and Cryosphere in a Changing Climate*. <https://www.ipcc.ch/srocc/>

2. Alternatively, National Oceanic and Atmospheric Administration (NOAA) develops three scenarios: (1) Low scenario: SLR 1.6 feet by 2100; (2) Intermediate scenario: SLR 1 foot by 2035 and 4 feet by 2100; (3) High scenario: SLR 2 feet by 2045 and 6.5 feet by 2100.

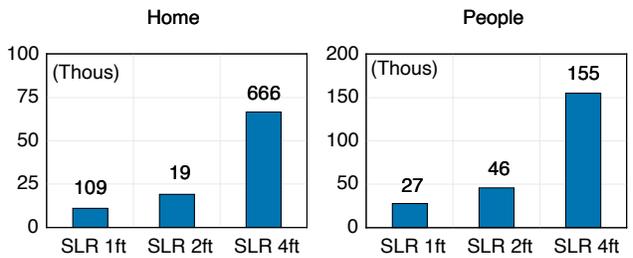
3. See its report "Underwater—Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate." And <https://ucsusa.maps.arcgis.com/apps/MapJournal/index.html?appid=0befd6dac46f4e0dbec2c3d8f539ab1a#>

total home values at risk of SLR by three scenarios: 1 foot (low scenario by IPCC and intermediate scenario by 2035 by NOAA), 2 feet (high scenario by 2045 by NOAA), and 4 feet (high scenario by IPCC and intermediate scenario by 2100 by NOAA). With an SLR of 1 foot, 10,900 homes on the California coastline would face chronic inundation<sup>4</sup>; 27,000 people would be impacted directly; and the loss of total home value would amount to \$11 billion. The number of homes and people impacted by SLR are from UCS, and the total estimated loss of property values are calculated from the percentage of homes impacted by SLR multiplied by the median home value in each zip code provided by American Community Survey (ACS) in 2018.<sup>5</sup> If we use Zillow’s median home value in October 2020, the total loss will rise to \$15.6 billion.

If the SLR reaches 2 feet, 19,000 homes in California will be at risk; 46,000 people will be impacted directly; and the loss of total home value will climb to \$20 billion (\$27 billion from Zillow’s median home value in Oct. 2020). If the SLR goes to 4 feet, 66,600 homes in California will be at risk; 155,000 people will be impacted directly; and the loss of total home value will surge to \$68 billion (\$93 billion from Zillow in Oct. 2020). Note that the economic loss of SLR on the local economy is not limited to loss of residential properties. Additional loss includes damage on commercial properties, foregone property tax revenues and foregone local consumption and business by residents.

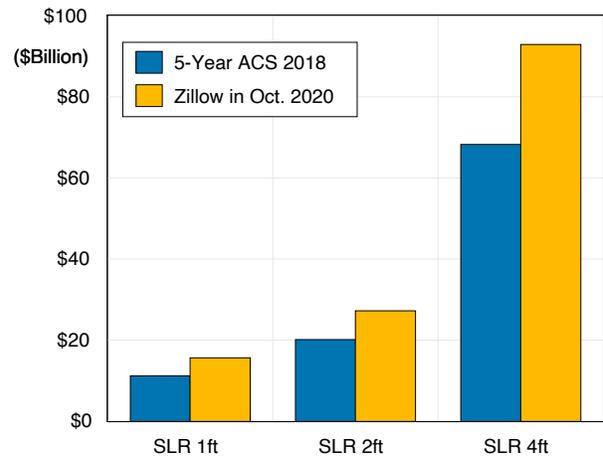
Based on 2018 ACS numbers, there were 136 million housing units in the U.S. and 14 million in California. The percentage of homes impacted by SLR in the U.S. and California are 0.1% in the U.S. and 0.08% in California with SLR of 1 foot; 0.22% in the U.S. and 0.13% in California with SLR of 2 feet; and 0.9% in the U.S. and 0.5% in California with SLR of 4 feet. That said, SLR risk on California real estate is milder than the national average. The real estate in Florida, on the East Coast, and in the Gulf Coast regions will face more severe damage than in California should SLR

Figure 1 Impact of Sea Level Rise on Number of Homes, People in California



Sources: Union of Concerned Scientists, American Community Survey and Author’s Calculation

Figure 2 Impact of Sea Level Rise on Total Home Value in California by Two Measures

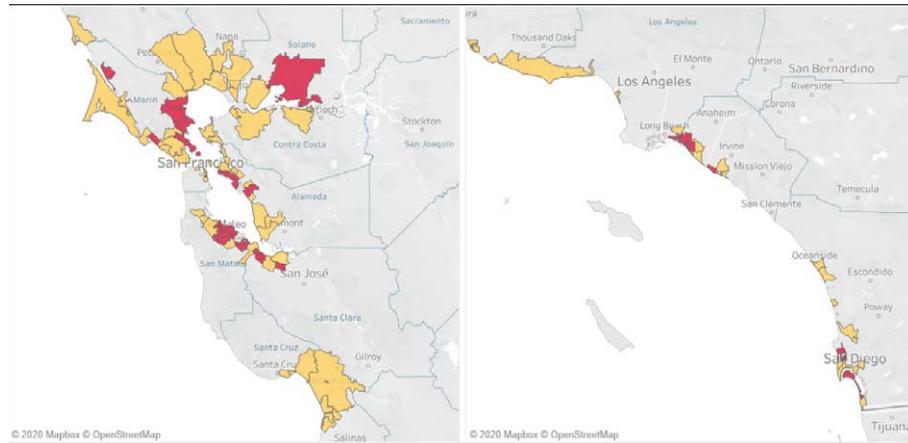


Sources: Union of Concerned Scientists, American Community Survey and Author’s Calculation

meet predictions. Murfin and Spiegel (2020)<sup>6</sup> estimate that Florida, New York, and New Jersey will encounter more loss of total home value than California due to SLR. In particular, Florida’s loss is estimated at around 5 times as California.

4. Chronic inundation refers to any area where high tide floods usable, non-wetland area at least 26 times per year.  
 5. It is a 5-year ACS, for the period of 2014 to 2018. So the median home value might reflect the value prior to 2018.  
 6. “Is the Risk of Sea Level Rise Capitalized in Residential Real Estate?” *Review of Financial Studies*, (2019), 33:3, pp 1217-1255

Figure 3 Zip Codes in California Impacted by Sea Level Rise of 4 Feet for Selected Regions in California



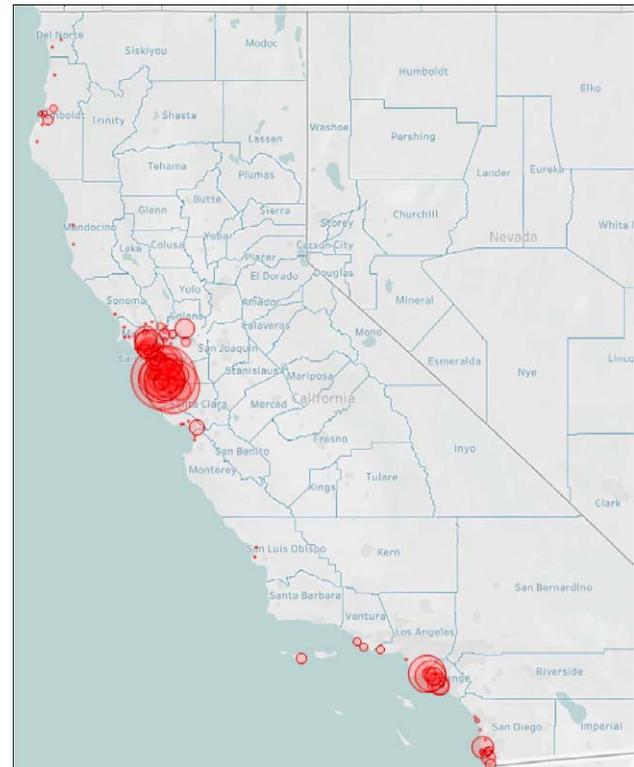
Sources: Union of Concerned Scientists, American Community Survey and Author's Calculation

### The Three Zones of Coastal California

To simplify the analysis, we use the intermediate scenario of SLR of 4 feet for the rest of the report. To show the degree of risk in California coastal zip codes impacted by SLR of 4 feet, we calculate the percentage of homes at risk of SLR over the total housing units for each zip code. There are about 111 zip codes facing risk from SLR of 4 feet with a varying degree of percentages of impacted housing units. For instance, the zip code with the highest percentage (77%) of housing units facing SLR risk is 94065 in Redwood City, followed by 94404 (64%) in Foster City and 92661 (46%) in Newport Beach. We arbitrarily categorize the zip codes with more than 4% of homes impacted by SLR of 4 feet as the Red Zone and the rest of the zip codes (below 4%) as the Yellow Zone. As shown in Figure 3, there are 30 zip codes in the Red Zone and 81 zip codes in the Yellow Zone. The details of zip codes in the Red and Yellow Zones are shown in the Appendix.

Figure 4 uses the size of circle to display the number of residents that will be directly impacted by SLR of 4 feet: the larger the circle, the more people will be affected. Similar to Figure 2, it is clear that the Bay Area would be the most impacted by SLR. For example, the zip code with the most people being impacted by SLR is 94404 in Foster City, in which there will be 23,000 people directly affected by SLR of 4 feet, followed by 94303 in Palo Alto with 16,000 people and 94403 in San Mateo with 11,400 people.

Figure 4 Number of People by Zip Code in California Impacted by SLR of 4 Feet



Sources: Union of Concerned Scientists, American Community Survey and Author's Calculation

### The Characteristics of the Three Zones

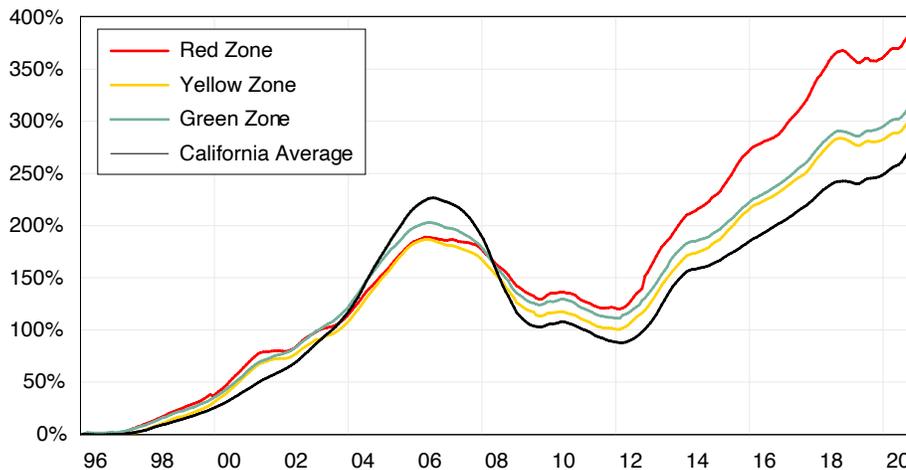
Now let’s take a look at the characteristics of housing markets in coastal California. It is worth noting that although for years we have heard of climate change and SLR risks on the coastline, coastal real estate is still in high demand in the U.S., whether in California or on any other coast. An ocean view and proximity to the beach continue to make these properties more expensive and attractive to buyers despite warnings of danger. This means the loss on homes due to SLR will be higher on coastal real estate than on an average house in the U.S.

According to Zillow, total housing values in the U.S. amount to \$33 trillion (median home value: \$205,000). Total home values in California are about \$7.3 trillion (median home value: \$476,000). Among 14 million housing units in California, 3.1 million units are in the coastal zip codes (within 5 miles of shoreline). Among these zip codes, there are 30 in

the Red Zone (with a total of 320,000 housing units) and 81 in the Yellow Zone (with a total of 846,000 units) as shown in Figure 2. The rest of the zip codes on the coastline (totaling 2 million housing units) are in the Green Zone, which is not at risk with SLR up to 4 feet.

Figure 5 presents the percentage change of home values<sup>7</sup> since 1996 for coastal California zip codes, in which the Red Zone is at high risk to SLR of 4 feet, the Yellow Zone is at medium risk, and the Green Zone is at low risk, as well as the average of California homes. If home buyers and investors are rational, aware of climate change and SLR risks, and consider it when making home purchase decisions, we might expect to see the price growth in the Red Zone slower than in the Yellow Zone, and the Yellow Zone’s slower than in the Green Zone’s, and the Green Zone’s slower than California’s average. This did not quite happen. Rather, the Red Zone had the highest growth rate of home value, and the Yellow Zone had higher growth than the California average.

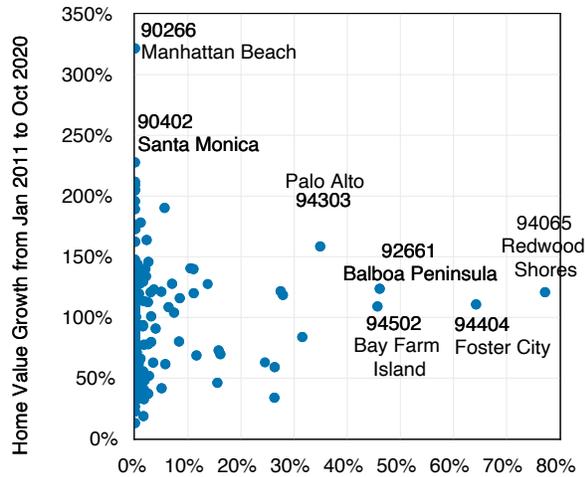
Figure 5 Percentage Change of Median Home Values in Coastal California Zip Codes and All of California Since 1996



Sources: Zillow and Author’s Calculation

7. Based on Zillow’s home values index for all houses (SFR and Condo), smoothed and seasonally adjusted.

Figure 6 Correlation between % of Homes Exposed to SLR of 4 Feet and Home Value Growth from January 2011 to October 2020 by Coastal Zip Codes in California



Sources: Union of Concerned Scientists, American Community Survey, Zillow and Author's Calculation

Figure 6 shows the correlation between percentage of homes exposed to SLR of 4 feet and home value growth from January 2011 to October 2020 by coastal zip codes in California. There is no clear correlation. If homebuyers and investors are concerned with SLR risk, we should see a negative correlation. But in fact, if we run a regression in which home value growth is the dependent variable with two explanatory variables – (1) the percentage of homes exposed to SLR and (2) whole zip-code population – we will get a significant and positive correlation. That means zip codes with more SLR risk have seen more home value growth after controlling for population. That is consistent to the outperforming Red Zone line in Figure 5.

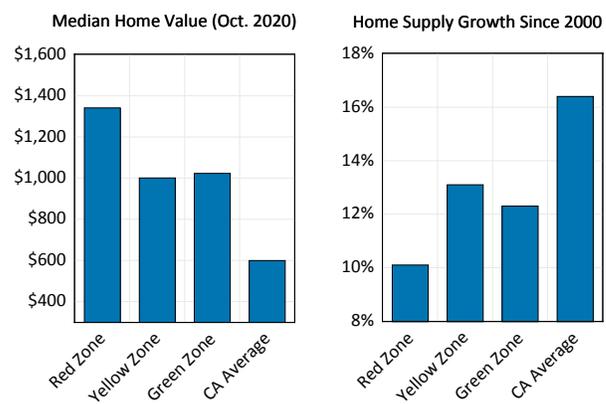
Figure 7 (left) illustrates the median home values from Zillow in October 2020 by three zones in coastal California and California as a whole. The median home value in the Red Zone is \$1,341,000 for two possible reasons: (1) superior amenities as mentioned before and (2) many zip codes are located in the heart of Silicon Valley, which has experienced a robust tech boom over the past several years. The median home value in the Yellow and Green Zones are both around \$1 million. If we assume that natural amenities are similar in these three zones, then there is no evidence of a price

discount due to SLR exposure. Note that the median rent could be more likely to reveal amenity value free of SLR concern. In other words, in terms of reacting to future SLR risk, price discount is more likely to be reflected in current home values than in the current rents by controlling the same amenity in the same zip code. So if homebuyers in California are rational, we should see that the ratio of home value to rent to be inversely correlated to % of home exposed to SLR. Figure 8 is the correlation of these two variables but we cannot see a significantly negative correlation.

Bernstein et al. (2019)<sup>8</sup> suggest that homes exposed to SLR sell for approximately 7% less than equivalent properties without exposure. Why did we not find it in California? There are two possible reasons: (1) They used individual property data while we use weighted average zip code data, or (2) They analyzed all coastal property in the U.S. It is likely that home price discount due to SLR is mostly driven in Florida and on the East and Gulf Coasts.<sup>9</sup>

Figure 7 (right) illustrates the home supply growth since 2000. The three zones in coastal California had lower housing supply growth than the whole of California for three possible reasons: (1) there is less space available on the coast, (2) it is more difficult to build on the coast, and (3) home builders, lenders, and local governments did factor the SLR risk into their decisions. Note that the Red Zone had

Figure 7 Median Home Values in October 2020 and Home Supply Growth Since 2000 in Coastal California Zip Codes and All of California

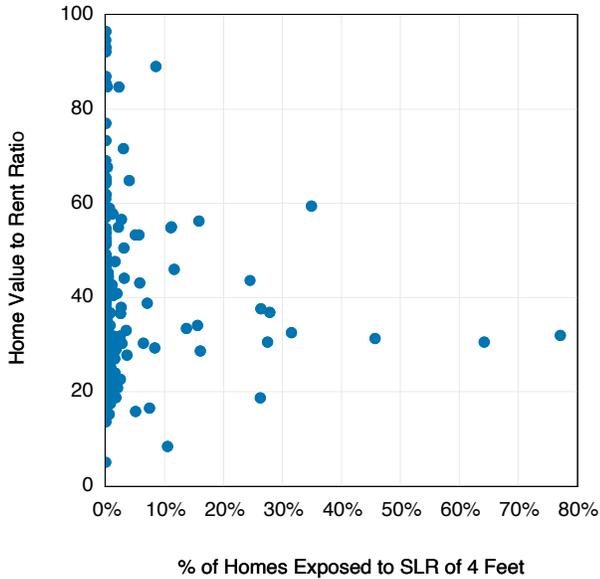


Sources: Zillow and American Community Survey

8. See Bernstein, Gustafson, and Lewis, "Disaster on the Horizon: The Price Effect of Sea Level Rise," *Journal of Financial Economics*, (2019), 134, pp 253-272.

9. See Figure 1 in their article (P257).

Figure 8 Correlation between % of Homes Exposed to SLR of 4 Feet and Ratio of Home Value to Annual Rents by Coastal Zip Codes in California

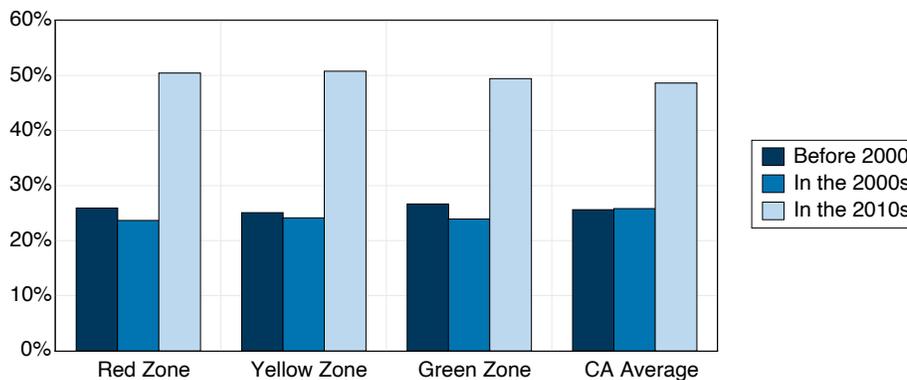


Sources: Union of Concerned Scientists, American Community Survey, Zillow and Author's Calculation

lower housing supply growth than the Yellow and Green Zones. That could suggest relatively risk-averse behavior, but a 10% growth might still be too high to indicate serious consideration of risk.

Figure 9 shows percentages of households (for both homeowners and renters) moved in by zone in three periods:

Figure 9 Percentages of Households Moved in by Three Periods in Coastal California Zip Codes and All of California



Source: American Community Survey

before 2000, during the 2000s, and during the 2010s. It is interesting to see that around 50% of residents have moved into their residence since 2010. We see a similar pattern across these three zones and in California as a whole. This could imply that SLR risk has not yet discouraged home purchases in the Red and Yellow Zones.

Would banks lend money to homebuyers when the collateral property might be at risk with SLR during its 30-year mortgage period? So far, the answer seems to be yes. Figure 10 presents the percentage of homes with mortgages by the three zones and in all of California. We do not see significant evidence that the Yellow Zone has less access to mortgages compared to the Green Zone, even though the Red Zone does have a slightly lower percentage of mortgages. Red Zone homeowners have higher mortgage costs compared to the Green Zone. It is unclear why the banks have not priced the SLR risk into their decisions.

The first possible reason could be that the average effective mortgage holding period is less than 30 years. In fact, Figure 9 suggests that the median duration of a mortgage holder staying in a house is around 10 to 15 years in California. That is, starting from 2020, the median mortgage will end by 2035 when the current homeowners move on. The second possible reason is that all these mortgages will be sold to Fannie Mae and Freddie Mac, two federal agencies who have a mandate to provide liquidity to homebuyers, and be turned into mortgage-back securities for investors. There might be some political reasons for Fannie and Freddie to not raise the price of mortgage on properties with high SLR risk.

Note that the high-risk flood insurance provided by the National Flood Insurance Program (NFIP) can only secure

coverage of up to \$250,000 for a residential building. That amount is significantly lower than a median home value in coastal California, making it less relevant when facing SLR risk. Will the insurance industry be able to provide some sort of market-rate climate insurance in the future to protect homeowners from SLR risks? It is likely, but we suggest the insurance premium will be extremely expensive because any SLR will hit all of the coastal U.S. at once. Unlike most other natural disasters, it will be difficult for insurers to diversify the SLR risk across the nation or the globe.

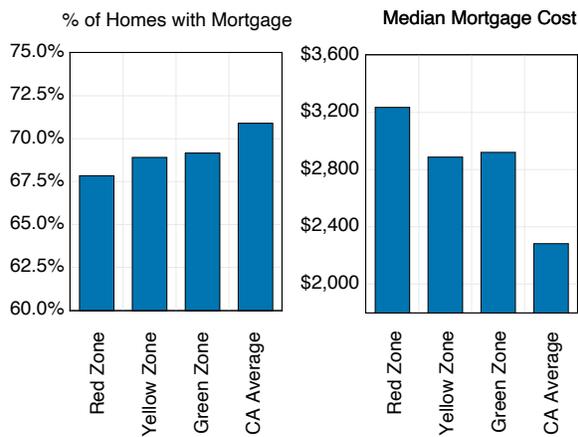
Figure 11 (left) displays the median household income in the three zones and all of California. It is not surprising to see the highest household income in the Red Zone, followed by the Green/Yellow Zone, which is consistent to the home values as shown in Figure 7. Figure 11 (right) shows that education level is consistent with homeowners' income level. That said, those who live in the Red Zone and are facing the highest risk of SLR in the future are also more educated and have the highest earning power. It is comforting to know they are more capable than middle-income or low-income households to navigate financial damage if faced with SLR in the future.

## California vs. Florida

Using the same data source from UCS, Keys and Mulder (2020)<sup>10</sup> suggest that since 2013 homebuyers started to factor in SLR, resulting in lower home sales volume (by 20%) in most SLR-exposed communities (similar to the Red Zone in this report) than in less SLR-exposed areas (Green Zone) in coastal Florida. And since 2018, home prices in the Red Zone started to grow more slowly than in the Green Zone in Florida. That article suggests that homebuyers became more aware of climate change and SLR risk partially because of events including severe damage on the East Coast caused by Hurricane Sandy in October 2012.

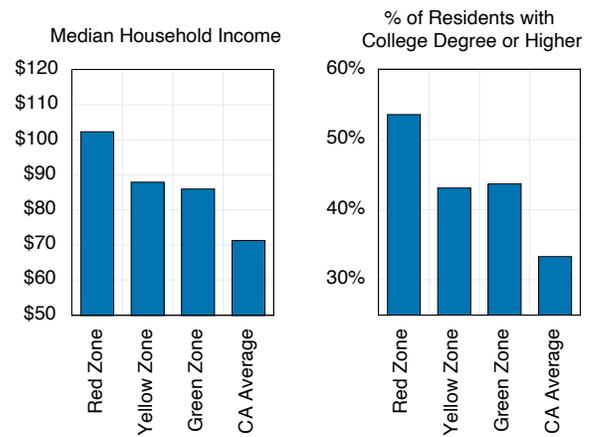
Why do we not see the same pattern in California? The first possible reason could be hurricanes do not strike the West Coast. Residents in California are less likely to imagine SLR risk compared to their Florida counterparts who have experienced horrific hurricane damage periodically.<sup>11</sup> The second possible reason is that SLR will affect homes in California later than in Florida as homes in California are in higher elevation than those in Florida. For example, according to California's Legislative Analyst's Office (LAO)'s

Figure 10 Percentage of Homes with Mortgage and Median Mortgage Cost in Coastal California Zip Codes and All of California



Source: American Community Survey

Figure 11 Median Household Income and Percentage of Residents with College Degree or Higher in Coastal California Zip Codes and All of California



Source: American Community Survey

10. See their paper, "Neglected No More: Housing Markets, Mortgage Lending, and Sea Level Rise," NBER Working Paper 27930.

11. One example is the following quote by Clifford Rossi, a former risk officer at both Fannie Mae and Freddie Mac, "It never reaches the point of people really kind of being forward-thinking about this until the crisis is upon you or about to hit you in the face." November 30, 2020, Politico. <https://www.politico.com/news/2020/11/30/climate-change-mortgage-housing-environment-433721>

report,<sup>12</sup> SLR will reach 1 foot in 2035 and 2 feet in 2060 in California coastline.

Using a comprehensive database of all of U.S. coastal home sales until 2017 merged with data on elevation relative to local cities, Murfin and Spiegel (2020)<sup>13</sup> suggest there is no evidence of a price discount for those homes subject to SLR risk. This implies there might be variation of perception, experiences, and reaction in response to SLR risk across coastal communities in the U.S. Californians for sure are now more aware of wildfire risks than residents in other states.

## Conclusions

The take-aways of the report are as follows:

- The projected impact of sea level rise (SLR) on coastal California housing markets are as follows:

- Number of homes affected -- 1 foot: 10,900, 2 feet: 19,000, 4 feet: 66,600
- Number of people affected -- 1 foot: 27,000, 2 feet: 46,000, 4 feet: 155,600
- Property value loss -- 1 foot: \$11 billion, 2 feet: \$20 billion, 4 feet: \$68 billion
- We divide coastal California zip codes into three zones by the percentage of housing units impacted by SLR of 4 feet: Green Zone (0%, 196 zip codes), Yellow Zone (below 4%, 81 zip codes), and Red Zone (above 4%, 30 zip codes).
- We do not find evidence that homebuyers have seriously factored SLR risk into their investment decisions in California. Red Zone houses are still in high demand by high-income and high-education households.

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12. "What Threat Does Sea-level Rise Pose to California?" August, 2020. <https://lao.ca.gov/Publications/Report/4261>

13. Murfin and Spiegel, "Is the Risk of Sea Level Rise Capitalized in Residential Real Estate?" (2020) *Review of Financial Studies*, 33:3, 1217-1255.

# SEA LEVEL RISE AND ITS IMPACT ON CALIFORNIA HOUSING MARKETS

## Appendix. Zip Codes in Red Zone and Yellow Zone of Coastal California

Zone	Zip Code	% of Home to SLR Risk	Total # of homes	Total population	Zone	Zip Code	% of Home to SLR Risk	Total # of homes	Total population
Red	94065	77.2%	5,275	12,579	Yellow	95076	1.5%	25,359	86,703
Red	94404	64.2%	15,149	36,905	Yellow	93035	1.4%	12,158	29,404
Red	92661	46.1%	2,568	3,225	Yellow	94111	1.3%	2,624	3,620
Red	94502	45.7%	5,262	14,619	Yellow	94559	1.2%	11,070	27,523
Red	94303	34.9%	14,699	48,039	Yellow	94070	1.2%	12,154	31,049
Red	94158	31.5%	4,265	7,291	Yellow	94603	1.1%	10,434	34,593
Red	94403	27.8%	17,241	44,300	Yellow	92101	1.1%	27,236	39,313
Red	94401	27.4%	13,511	35,414	Yellow	92106	1.0%	8,074	19,080
Red	94925	26.3%	4,053	9,866	Yellow	94801	0.9%	10,311	29,958
Red	95564	26.2%	202	432	Yellow	95501	0.8%	11,107	23,467
Red	90803	24.4%	18,166	32,389	Yellow	92104	0.8%	23,304	45,202
Red	94940	23.9%	138	234	Yellow	95039	0.7%	424	1,195
Red	94949	16.0%	7,721	17,452	Yellow	94945	0.7%	7,503	19,035
Red	94939	15.8%	3,520	7,108	Yellow	95551	0.6%	665	1,374
Red	92649	15.5%	15,082	34,406	Yellow	92660	0.6%	16,942	36,906
Red	94063	13.7%	10,598	34,503	Yellow	94010	0.5%	17,378	42,730
Red	94970	12.9%	874	689	Yellow	94589	0.5%	10,097	30,668
Red	94901	11.6%	16,336	42,482	Yellow	94565	0.5%	29,369	96,081
Red	92663	11.1%	12,246	21,572	Yellow	90815	0.5%	14,883	41,026
Red	94402	11.0%	10,225	25,764	Yellow	95555	0.4%	224	337
Red	94089	10.5%	8,474	22,313	Yellow	94965	0.4%	6,459	11,408
Red	94920	8.5%	5,954	12,797	Yellow	92107	0.3%	14,706	31,148
Red	94903	8.3%	12,587	30,048	Yellow	94710	0.3%	3,231	7,461
Red	94585	7.4%	9,572	29,599	Yellow	92008	0.3%	13,051	27,330
Red	94501	7.0%	26,889	63,843	Yellow	94608	0.3%	15,194	30,289
Red	94577	6.4%	17,922	48,088	Yellow	92625	0.2%	6,804	12,148
Red	92109	5.7%	26,213	48,417	Yellow	94555	0.2%	11,941	38,388
Red	92118	5.6%	10,884	22,484	Yellow	95012	0.2%	2,739	10,792
Red	90740	5.1%	13,714	24,494	Yellow	94956	0.2%	916	1,224
Red	94002	5.0%	11,015	27,202	Yellow	94956	0.2%	916	1,224
Yellow	94904	3.9%	5,665	12,590	Yellow	95548	0.2%	582	1,224
Yellow	94587	3.6%	22,455	74,601	Yellow	94043	0.2%	13,777	31,488
Yellow	93013	3.4%	7,565	16,644	Yellow	95410	0.2%	629	1,159
Yellow	94030	3.1%	8,591	22,710	Yellow	95536	0.2%	1,270	2,898
Yellow	94941	3.1%	14,226	32,013	Yellow	90293	0.2%	7,059	12,694
Yellow	94025	3.0%	16,036	42,788	Yellow	94130	0.1%	708	3,064
Yellow	92647	2.7%	22,068	62,718	Yellow	95010	0.1%	4,847	9,030
Yellow	94937	2.6%	732	816	Yellow	94601	0.1%	16,489	52,299
Yellow	94607	2.6%	12,397	26,254	Yellow	94503	0.1%	5,639	20,306
Yellow	94107	2.5%	15,981	29,689	Yellow	93402	0.1%	6,850	16,350
Yellow	95503	2.5%	10,799	25,503	Yellow	94553	0.1%	19,612	49,699
Yellow	94066	2.5%	15,238	43,124	Yellow	92121	0.1%	1,883	4,655
Yellow	90265	2.2%	9,818	18,389	Yellow	94804	0.0%	15,303	41,510
Yellow	91932	2.1%	10,488	26,701	Yellow	92054	0.0%	17,787	42,173
Yellow	94924	2.1%	858	1,134	Yellow	92054	0.0%	17,787	42,173
Yellow	94590	2.0%	16,069	37,377	Yellow	94606	0.0%	16,245	38,303
Yellow	92648	1.9%	21,180	46,890	Yellow	95062	0.0%	16,798	38,028
Yellow	94579	1.8%	7,310	22,040	Yellow	94123	0.0%	15,200	25,941
Yellow	94572	1.7%	3,395	10,411	Yellow	95476	0.0%	17,420	36,792
Yellow	93041	1.7%	8,463	24,506	Yellow	92007	0.0%	4,838	11,234
Yellow	95002	1.7%	594	2,146	Yellow	94105	0.0%	6,403	9,155
Yellow	95521	1.6%	9,470	21,462	Yellow	93442	0.0%	6,505	10,976
Yellow	94923	1.6%	1,286	846	Yellow	95437	0.0%	7,072	14,632
Yellow	94545	1.6%	9,675	32,525	Yellow	95531	0.0%	9,535	23,470
Yellow	94510	1.5%	11,698	28,262	Yellow	95003	0.0%	11,883	24,837
					Yellow	94954	0.0%	14,138	38,414