Impact of Sea-Level Rise on the Mid- and Upper-Atlantic Coast

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Introduction

This study is conducted for the Consortium for the Atlantic Regional Assessment (CARA), a research and outreach effort funded by EPA to provide scientific information and tools through internet resources that decision makers can use for exploring and adapting to potential impacts from changes in land use and climate in the mid- and upper-Atlantic region (Figure 1). Previous studies suggest that by the end of this century climate change could raise sea level by 2 feet on average, ranging from 1.5 to 3.5 feet, for the Atlantic coastal region. This study aims to quantitatively assess the impact of sea-level rise by achieving the following two objectives. First, we make projections of future sea level for different parts of the mid- and upper-Atlantic coast, based on subsidence rate and climate model output. Second, we apply GIS models to combine topographic, land use, census and transportation data to show the potential impact of projected sea-level rise in each of the 85 coastal counties from Massachusetts to Virginia.

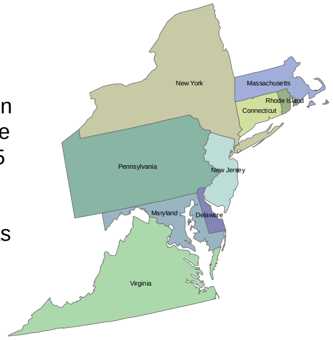


Figure 1: CARA Study Area

Part I: Sea Level Rise Projections

Relative sea-level rise along the Atlantic coast has two components: absolute sea-level rise and subsidence. Church et al (2004) estimate that global sea level rose at 1.8 ± 0.3 mm/y between 1950 and 2000 (see Figure 2). We quantify subsidence by removing this rate of observed global sea-level rise from the observed sea-level rise over the last 50 years at 29 water level monitoring stations throughout the region. We then make projections of future sea-level using the estimated subsidence rate and projections of global sea level from five climate models run under two greenhouse gas emission scenarios (A2 and B2). The methodology is summarized below:

$$\Delta H_R(t,\mathrm{x}) = \Delta H_A(t) + [\alpha_R(\mathrm{x}) - \alpha_A](t - t_0)$$

Where: Reference time t_0: 2000

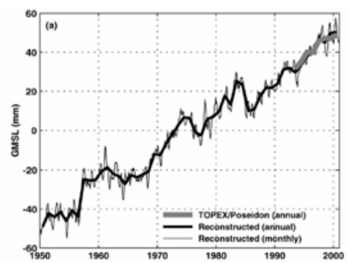
$\Delta H_R(t,\mathbf{x})$: SLR at a given station and time

$\Delta H_A(t)$: Sea level rise (SLR) given by GCM

$\alpha_R(\mathbf{x})$: Relative SLR

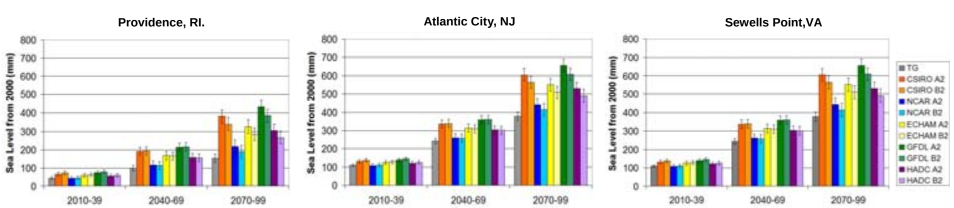
α_A: Observed absolute SLR

Figure 2: Global Mea Sea Level 1950-2000 (Church et al, 2004)



Results for selected monitoring stations are presented in Figure 3.

Figure 3: Projected sea level rise for selected stations
(TG is the linear extrapolation of the tide gauge data. Error bars reflect estimated error in subsidence rate.)



Conclusions

Sea level is projected to rise between 0.4-0.7 meter (1.4-2.3 feet) for the CARA region. Relative sea-level rise is expected to be less in northern states than southern states because of smaller subsidence rates in the north. For the same reason, sea level is likely to rise less at locations farther inland. There is relatively small variation between scenarios, but larger variation among the models.

Part II: Potential impacts of sea-level rise

In order to make the sea level projections more useful for decision makers, they need to be translated into the area affected by sea-level rise. In the next step, we use GIS models to combine topographic, land use, census and road network data to show the potential impact of projected sea-level rise in each of the 85 coastal counties from Massachusetts to Virginia. Five elevation zones are mapped along with current open water: 1) land areas below 0 feet; 2) areas 0 to 3 feet; 3) areas 3 to 6 feet; 4) areas 6 to 9 feet; and 5) areas above 9 feet. Zones 1 and 2 are likely to be completely inundated with future sea-level rise. Zones 3 and 4 are likely to become future tidal land. Zone 5 is considered safe from sea-level rise. Such delineation allows flexibility in using these maps to accommodate uncertainties in sea-level rise projections as well as local variations in tidal range and sea-level rise. For each county, a map shows these elevation zones (Figures 4 and 5); quantities of land area in different zones are calculated and presented in tables (Table 1). In addition, the map of elevation zones is overlaid with land use and 2000 Census block information to calculate the breakdown of different land use types and the number of people living in these elevation zones (Tables 2-4). All of the information (maps and tables) is provided to the stakeholders through the CARA website, so that they can explore interactively the maps showing areas at risk of sea-level rise and other related information.

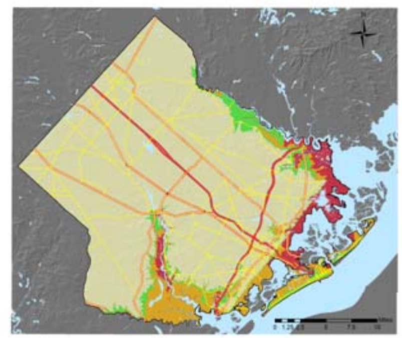


Figure 4: Area vulnerable to sea-level rise in Atlantic County, NJ

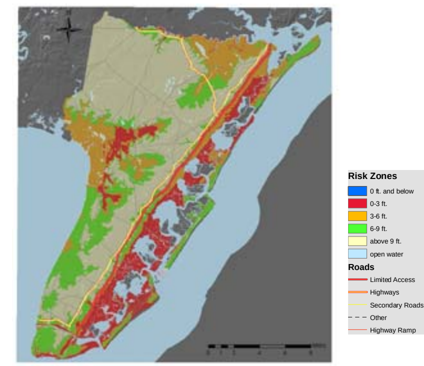


Figure 5: Area vulnerable to sea-level rise in Cape May County, NJ

Quantitative Data for Atlantic County, NJ

Table 1: Area Vulnerable to Sea-Level Rise

Zones	Area (sq. mi)	%
below 0 ft	4.1	0.7
0 – 3 ft	29.4	5.4
3 – 6 ft	44.8	8.3
6 – 9 ft	24.8	4.5
above 9 m.	446.7	81.3
Total	549.8	100

Table 2: Number of People Vulnerable to Sea-Level Rise

Zones	# of People	%
below 0 ft.	989	0.4
0 - 3 ft.	6570	2.6
3 - 6 ft.	47751	18.9
6 - 9 ft.	34403	13.6
above 9 ft.	162661	64.5
total	252373	100.00

Table 3: Land Use in Risk Zones (sq. mi)

Zone	0 ft. & Below	0-3 ft.	3-6 ft.	6-9 ft.	Above 9 ft.
Open Water	2.85	5.97	2.65	0.42	3.65
Developed	0.19	1.01	5.52	4.64	44.39
Barren	0.01	0.01	0.32	0.07	5.45
Forest	0.28	4.14	12.57	8.73	276.35
Agriculture	0.01	0.25	1.26	1.45	62.03
Wetland	0.75	18.01	22.52	9.46	54.88

Table 4: Road Vulnerable to Sea-Level Rise (mi)

Risk Zone	Limited Access Highway	Highway	Secondary Roads	Other
Below 0 ft	2	4	7	0
0 - 3 ft	50	30	25	2
3 - 6 ft	59	50	86	5
6 - 9 ft	43	45	153	5
above 9 ft	105	147	352	23
total	259	276	623	34

Conclusions

In the CARA region, approximately one thousand square miles of land area lies below 3 feet, and is hence highly vulnerable to sea-level rise. Within this area, about 70 square miles are developed land. About 388 thousand people live in this high risk zone (below 3 ft). Nearly three thousand miles of roads are exposed to such high risk of inundation with projected sea-level rise. In general, southern states (e.g. NJ and VA) have more area, people and facilities lying in high risk zones because of gentler terrain and more development along the coast.

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