TESTIMONY OF BRENDA EKWURZEL, Ph.D.

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UNION OF CONCERNED SCIENTISTS

July 17, 2015

BEFORE THE

COMMITTEE ON ENERGY AND COMMERCE

U.S. HOUSE OF REPRESENTATIVES

THE HONORABLE FRANK PALLONE, JR, RANKING MEMBER

DEMOCRATIC FIELD FORUM "CLIMATE CHANGE AT THE WATER'S EDGE"

AT THE UNITED STATES NAVAL ACADEMY, ANNAPOLIS, MARYLAND

Summary of Union of Concerned Scientists Testimony

- The burning of fossil fuels and other human activities is causing the atmosphere and the oceans to warm, which is accelerating the rise of sea level and increasing the frequency and severity of coastal flooding.
- The rate and amount of heat trapping emissions we reduce (or increase) correlates to the severity of climate impacts like sea level rise and flooding
- Annapolis, Maryland currently experiences roughly 50 tidal flooding events a year, but the capital could see as much as 17 inches of sea level rise and 380 tidal flooding events a year by 2045 under a business as usual scenario for greenhouse gas emissions.
- Ocean City, Maryland currently experiences just over 7 tidal flooding events per year, but the city could see as much as 18 inches of sea level rise and 411 tidal flooding events a year by 2045 under a business as usual scenario for greenhouse gas emissions.
- Baltimore, Maryland currently experiences 17 tidal flooding events per year, but the city could see as much as 17 inches of sea level rise and 381 tidal flooding events a year by 2045 under a business as usual scenario for greenhouse gas emissions.
- Cambridge, Maryland currently experiences 10 tidal flooding events per year, but the city could see as much as 17 inches of sea level rise and 456 tidal flooding events a year by 2045 under a business as usual scenario for greenhouse gas emissions.
- Several locations in the Chesapeake Bay area, including Baltimore Inner Harbor, are projected to be underwater for more than 875 hours a year—10 percent of the time—by 2045.
- Warmer ocean temperatures are fueling stronger North Atlantic storms. Stronger storms riding on higher tides significantly increase the breath and severity of flooding, causing even more damage.

Testimony

On behalf of the Union of Concerned Scientists (UCS), I would like to thank Ranking Member Pallone, Congressman Sarbanes, and the rest of the Energy and Commerce Committee Members in attendance for the opportunity to testify today. My name is Brenda Ekwurzel. I am the Senior Climate Scientist at UCS, the nation's leading science-based nonprofit organization with more than half a million members and supporters. We put rigorous, independent science to work to solve our world's most pressing problems.

Burning coal, oil, gas and tropical deforestation have led to increased atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years (Lüthi et al. 2008). This build-up of heat-trapping gases is warming up the atmosphere and acidifying the oceans at an unprecedented pace. As a result, corals and other marine life facing multiple risks, snowpack and ice have diminished, exacerbating drought in many regions and making wildfires more intense. Sea levels have accelerated, extreme precipitation has increased, and that's in part why we've also seen more severe flooding, especially in cities like Annapolis. The pace and amount of greenhouse gas emissions determine how much worse things get.

So-called "Business as Usual" trajectory, determined from the recent pace of emissions, is an additional +5C (+9 F) global mean surface temperature. What does this mean on the ground? An additional 3°C of warming 3-12 countries lose more than half of their current land surface, 25-36 counties lose at least 10% of their territory and 7% of the global population currently lives in regions that would be below local sea level (Table 1; Marzeion and Levermann 2014).

So what does this mean for Maryland the location of this Field Hearing?

Parts of Maryland are already facing risks of land loss. Everyone who cares about Maryland should care about reducing emissions; the future of key economic resources and cherished places of the state depends on it (Holtz et al. 2014). Today, the capital, Annapolis, is one of the most frequently flooded cities on the east coast and as sea level rise accelerates due to climate change, the flooding will get exponentially worse. There are countless other communities up and down the Maryland coast that are similarly vulnerable.

According to a recent UCS report called "Encroaching Tides," the highest tides that occur each year are flooding further inland and some of the land is likely to be underwater over the lifetime of a Home Mortgage policy (Sweet et al. 2014; Spanger-Siegfried, Fitzpatrick, and Dahl 2014).

Recent trends help explain why this is happening. Over the last 50 years seal level rise has risen much faster along the gulf and east coast than along most other parts of the world (Figure 1) (Ishii et al. 2006; Milne 2008). Sea level at Annapolis has risen by more than a foot over the last century—much higher than the global rate of sea level rise of 8 inches over around the last century (1880-2010) (Church and White 2011). To give an idea of the accelerating pace of sea level rise let's examine the prospects for Annapolis.

If the we stay on our current high trajectory (Table 2) of greenhouse gas emissions, Annapolis would likely see 8 inches of sea level rise just 15 years from now (by 2030) and by just the life time of the average home mortgage(by 2045), Annapolis would likely see roughly 17 inches of sea level rise (Table 3). If instead we embarked upon an intermediate-low emissions trajectory Annapolis could prepare for only around and addition 3 inches in 15 years and over 6 inches by 30 years hence (Table 3) (Spanger-Siegfried, Fitzpatrick, and Dahl 2014).

Today the popular City Dock—a central meeting place along the waterfront in Annapolis—sees flooding around 50 times a year during high tides. Annapolis is projected to experience roughly 262 tidal flooding events a year by 2030 and roughly 380 by 2045, if we stay on our current high trajectory of greenhouse gas emissions (Table 3). In other words, if these flood events last more than several hours, and there are two tides a day, and only 365 days a year, this means likely half the days of the year with flooding at Annapolis.

Other coastal communities in Maryland are similarly vulnerable. Because it sits on a fragile barrier island, Ocean City is highly vulnerable to flooding from storms and high tides— more so with sea level rise. While tidal flooding occurs about eight times a year today, if we stay on our current high trajectory of greenhouse gas emissions, the city could face as much as 60 tidal floods each year by 2030, and a whopping 411 per year just 30 years from now (Table 3). These floods would be far more extensive than the limited flooding typically seen today—more along the lines of flooding associated with heavy rain or strong winds. The case for emissions reductions could not be more direct. If instead we limited emissions to the low-intermediate trajectory, Ocean City could prepare for around 42 flood events by 2045 (Table 3).

Our analysis indicates that Baltimore could experience as much as 115 tidal flooding events by 2030, and over 380 tidal flooding events by close to mid-century if we stay on our current high emissions trajectory (Table 3). Likewise, Cambridge Maryland could experience as much as 90 tidal flooding events by 2030, and more than four times that by mid-century if we don't reduce our greenhouse gas emissions (Table 3).

Tidal floods will also be more severe in both duration and extent by 2045. Today tidal floods typically last a few hours or less. Annapolis, MD now sees flood conditions for more than 85 hours each year, or more than 1 percent of the time. But by 2045, Annapolis (as well as Ocean City) can expect flood-prone areas to spend more than 345 hours per year underwater, or more than 5 percent of the time. And several locations in the Chesapeake Bay area, including Baltimore and its flood-prone Inner Harbor, are projected to be underwater for more than 875 hours a year—10 percent of the time—by 2045.

Sea level rise means even regular waves and periodic storms worsen coastal erosion in coming decades, exposing Ocean City to even more flooding (Zhang, Douglas, and Leatherman 2004; Titus et al. 1985). Even when a hurricane forms naturally, conditions brought about by climate change are contributing to the power and destructive capacity of hurricanes in the North Atlantic through more severe storm surges and more intense precipitation (Knutson et al. 2010; Lin et al. 2012). To make matters worse, the latest science suggests that hurricanes, typhoons, and cyclones are shifting poleward at a rate of one degree latitude per decade where these reach their lifetime-maximum intensity over the past 30 years (Kossin, Emanuel, and Vecchi 2014). Not a welcome trend for U.S. East coast residents.

Storm surges associated with hurricanes and other storms have caused the water to ascend three feet or more above mean sea level at least 10 times in Annapolis during the last decade. Resulting damage can be expected to worsen in the future, as rising seas not only raise the frequency of floods from regular high tides but also increase the height of storm surges.

The US and the global community of nations must start rapidly reducing their emissions of heat trapping gases to slow the pace of sea level rise, and to avoid the worst impacts of climate change. The future welfare of Maryland and other coastal states and nations depends on it.

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Tables:

Table 1. No. of countries and UNESCO *cultural* and *mixed* world heritage sites, and percentages of UNESCO *cultural* and *mixed* world heritage sites, distribution of current global population, and land surface area impacted by SLR at different global mean temperature anomalies ΔT. Uncertainty ranges are given in parenthesis.

			Global mean ΔT (K)				
			1	2	3	4	5
No. of	Countries	$\geq$10%	9 (0–20)	26 (15–33)	35 (25–36)	38 (36–43)	41 (36–45)
		$\geq$50%	0 (0–0)	3 (0–6)	7 (3–12)	12 (8–13)	13 (10–13)
No. of	UNESCO sites		47 (20–102)	110 (79–140)	136 (111–155)	148 (139–159)	149 (142–161)
% of			6.5 (2.8–14.1)	15.3 (11.0–19.4)	18.9 (15.4–21.5)	20.6 (19.3–22.1)	20.7 (19.7–22.4)
% of	Current population		2.2 (1.3–3.9)	4.7 (3.6–7.2)	6.9 (5.1–9.0)	9.1 (7.9–10.8)	10.5 (8.8–11.6)
	Surface area		0.7 (0.7–0.8)	0.9 (0.8–1.1)	1.1 (0.9–1.2)	1.5 (1.2–1.6)	1.6 (1.2–1.8)

Source: Marzeion and Levermann (2014) Environmental Research Letters

TABLE 2. **Assumptions for Emissions, Ice Loss, and Ocean Warming for the National Climate Assessment Sea Level Rise Scenarios**

Scenario	Global Average SLR by 2100 (meters)	Global Average SLR by 2100 (feet)	Scenario Assumptions			
			Emissions Scenario	Ice	Oceans	Notes
Highest Scenario	2.0	6.6	A1B	Maximum loss on land ice.[a]	Warm as projected by IPCC AR4	This scenario combines maximum ice loss and a level of ocean warming associated with a middle-of-the-road emissions scenario (A1B) to calculate future sea level rise.
Intermediate-High Scenario	1.2	3.9	Models employ a range of IPCC AR4 SRES scenarios.[b]	Ice loss increases throughout the 21st century comes to dominate total sea level rise. Ice loss is simulated as a response within climate models.	Thermal expansion is simulated as a response within climate models. Its contribution to total sea level rise over the 21st century gradually declines.	This scenario represents the average of the high end of semi-empirical models that use observed data to extrapolate into the future.[c] Models rely on the existing observed relationships between global temperature and the rate of sea level rise, ice loss, and thermal expansion to project how future warming will affect Earth systems and, ultimately, cause sea level rise.
Intermediate-Low Scenario	0.5	1.6	B1	Minimal ice sheet loss	Warming as per IPCC AR4 B1	This scenario assumes aggressive decreases in GHG emissions. Sea level rise is primarily driven by thermal expansion, with minimal ice loss.

a: as modeled by Pfeffer, Harper, and O'Neel 2008
b: Vermeer and Rahmstorf 2009; Jevrejeva, Moore, and Grinsted 2010
c: i.e. Vermeer and Rahmstorf 2009; Horton et al. 2008; Jevrejeva, Moore, and Grinsted 2010

DATA SOURCE: ADAPTED FROM PARRIS ET AL. 2012

Table 2. From Table 2 in Technical Appendix (Spanger-Siegfried, Fitzpatrick, and Dahl 2014).

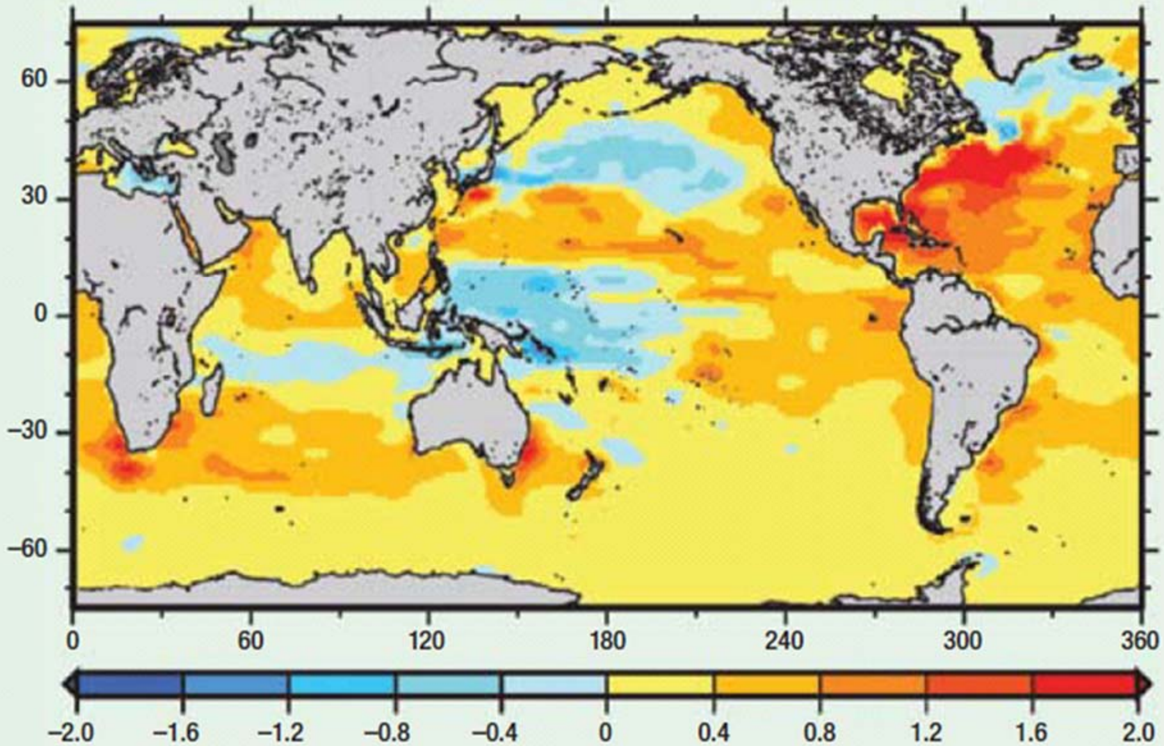
Table 3. From Table 4 in Technical Appendix (Spanger-Siegfried, Fitzpatrick, and Dahl 2014)

					Intermediate-Low Scenario				Intermediate-High Scenario				Highest Scenario					
State	Tide Gauge	Gauge #	Record Start	Events Today	SLR 2030 (in)	Events 2030	SLR 2045 (in)	Events 2045	SLR 2030 (in)	Events 2030	SLR 2045 (in)	Events 2045	SLR 2030 (in)	Events 2030	SLR 2045 (in)	Events 2045	Nearest Projection	Miles to Projection
CT	Bridgeport	8467150		21.6	3.0	42.0	6.0	73.2	5.1	62.0	11.3	162.4	7.6	93.2	16.8	295.2		
CT	New Haven	8465705	1964	7.2	3.0	15.2	6.0	30.8	5.1	25.2	11.3	86.4	7.6	43.2	16.8	199.4	Bridgeport	27
CT	New London	8461490		2.2	3.0	4.2	6.1	9.8	5.2	7.2	11.4	36.6	7.6	15.0	16.9	135.6		
DC	Washington, DC	8594900	1938	43.2	3.3	94.8	7.1	208.2	5.4	155.4	11.9	388.2	7.9	241.0	17.4	544.4		
DE	Lewes	8557380	1924	28.4	3.6	55.6	7.0	106.4	5.7	87.2	12.4	222.6	8.2	127.2	17.9	372.6		
DE	Reedy Point	8551910	1919	14.6	3.8	41.8	7.5	109.4	5.9	76.4	12.8	256.8	8.4	128.8	18.3	441.4		
FL	Apalachicola	8728690	1956	0.6	2.1	1.0	4.5	0.8	4.3	0.8	9.7	2.8	6.8	1.2	15.3	13.0		
FL	Clearwater Beach	8726724	1967	0.2	2.9	0.2	5.8	1.6	5.0	1.4	11.1	5.2	7.5	2.4	16.6	43.0		
FL	Fernandina Beach	8720030	1973	1.8	2.6	4.0	5.3	10.6	4.7	8.0	10.5	36.8	7.2	16.6	16.1	105.6		
FL	Key West	8724580	1987	3.0	2.8	19.0	5.7	37.2	5.0	45.2	11.0	211.6	7.4	95.2	16.5	435.4		
FL	Mayport	8720218	1913	6.6	2.6	13.0	5.3	29.8	4.7	25.2	10.5	101.2	7.2	50.0	16.1	242.6	Fernandina Beach	19
FL	Panama City	8729108		0.0	2.1	0.0	4.5	0.4	4.3	0.2	9.7	3.4	6.8	0.6	15.3	21.8	Apalachicola	51
FL	St. Petersburg	8726520		0.0	3.0	0.2	6.0	0.6	5.1	0.6	11.2	1.0	7.6	0.6	16.8	2.6		
FL	Vaca Key	8723970	1947	0.4	3.3	1.4	6.5	11.2	5.4	5.6	11.8	88.0	7.9	21.2	17.3	263.6		
FL	Virginia Key	8723214	1971	5.8	3.3	23.6	6.5	66.4	5.4	47.6	11.8	237.2	7.9	94.6	17.3	510.8	Vaca Key	92
GA	Ft. Pulaski	8670870		9.6	3.3	21.2	6.6	45.0	5.4	36.8	11.9	113.4	7.9	63.0	17.4	220.4		
LA	Lawma, Amerada Pass	8764227	1935	0.0	7.4	0.2	14.1	1.0	9.6	0.4	19.4	5.0	12.0	0.8	24.9	21.2	Grand Isle	84
MA	Boston	8443970		11.2	2.9	21.8	5.8	33.8	5.0	31.2	11.1	71.8	7.5	45.0	16.7	136.0		
MA	Nantucket Island	8449130	1921	0.6	3.5	1.6	6.9	3.8	5.6	3.0	12.2	11.6	8.1	4.8	17.7	31.6		
MA	Woods Hole	8447930	1965	0.2	3.0	0.2	6.1	0.2	5.2	0.2	11.4	0.4	7.7	0.2	16.9	2.2		
MD	Annapolis	8575512	1932	49.8	3.4	122.0	6.7	224.0	5.5	186.8	12.0	368.4	8.0	262.8	17.5	380.8		
MD	Baltimore	8574680	1928	17.0	3.3	36.2	6.5	84.2	5.4	63.2	11.8	226.8	7.9	115.6	17.3	381.0		
MD	Cambridge	8571892	1902	10.0	3.7	27.4	7.4	70.2	5.9	45.8	12.7	242.4	8.4	90.2	18.2	456.0		
MD	Ocean City	8570283	1943	7.6	3.6	18.2	7.0	42.6	5.7	29.6	12.4	173.4	8.2	59.6	17.9	411.6	Lewes	31
MD	Tolchester Beach	8573364	1975	4.4	3.3	9.0	6.5	20.8	5.4	16.2	11.8	78.4	7.9	29.4	17.3	226.4	Baltimore	45
ME	Portland	8418150		11.2	2.1	19.6	4.3	30.2	4.2	30.0	9.6	64.6	6.7	42.4	15.2	124.6		
MS	Bay Waveland Yacht Club	8747437	1912	12.8	2.5	22.0	5.2	41.2	4.7	37.4	10.5	110.4	7.1	60.2	16.0	223.4	Pensacola	83
NC	Duck	8651370		8.2	4.5	19.0	8.8	48.4	6.7	32.2	14.1	126.0	9.1	51.0	19.6	265.2	Sewells Point	62
NC	Wilmington	8658120	1978	44.4	2.5	88.6	5.1	143.2	4.6	133.2	10.4	343.0	7.1	209.8	15.9	557.8		
NC	Wrightsville Beach	8658163	1935	8.0	2.5	17.0	5.1	32.0	4.6	29.0	10.4	89.6	7.1	50.0	15.9	185.6	Wilmington	10
NJ	Atlantic City	8534720		31.8	4.3	67.8	8.3	125.2	6.4	92.0	13.7	244.2	8.9	134.6	19.2	391.0		
NJ	Cape May	8536110	1911	40.6	4.2	92.0	8.3	167.2	6.4	128.4	13.6	302.4	8.9	179.2	19.1	454.4		
NJ	Sandy Hook	8531680	1965	33.0	3.2	59.4	6.4	103.4	5.4	87.8	11.7	210.6	7.8	127.0	17.3	356.4	The Battery	16
NY	Bergen Point	8519483	1932	14.2	3.2	30.8	6.4	53.2	5.4	45.2	11.7	129.8	7.8	71.4	17.3	258.6	The Battery	8
NY	Kings Point	8516945		22.4	3.2	40.2	6.4	67.6	5.4	57.2	11.7	142.0	7.8	82.4	17.3	264.0	The Battery	15
NY	Montauk	8510560		3.0	3.5	6.4	6.9	14.8	5.6	10.2	12.2	52.2	8.1	19.0	17.7	168.8		
NY	The Battery	8518750	1947	5.4	3.2	9.4	6.4	20.8	5.4	16.2	11.7	58.8	7.8	28.6	17.3	148.4		
PA	Philadelphia	8545240	1856	19.0	3.8	39.8	7.5	95.4	5.9	66.0	12.8	206.2	8.4	112.8	18.3	367.0	Reedy Point	35
RI	Newport	8452660		0.0	3.0	0.8	6.1	1.8	5.2	1.4	11.4	8.4	7.6	2.4	16.9	33.6		
RI	Quonset Point	8454049	1930	0.0	3.0	0.0	6.1	0.6	4.9	0.4	10.8	3.2	7.3	1.0	16.3	13.8	Newport	7
SC	Charleston	8665530		24.2	3.1	50.4	6.2	94.0	5.2	78.2	11.5	187.4	7.7	114.8	17.0	347.0		
SC	Springmaid Pier	8661070	1921	3.6	3.6	8.4	7.2	21.0	5.8	14.6	12.4	65.6	8.2	26.4	18.0	139.4		
TX	Eagle Point	8771013	1957	0.0	5.5	0.2	10.7	2.2	7.7	0.8	16.0	10.8	10.2	2.2	21.5	40.8	Galveston Pier 21	14
TX	Galveston Pier 21	8771450		0.0	5.5	0.2	10.7	2.4	7.7	1.0	16.0	11.6	10.2	2.4	21.5	53.6		
TX	Rockport	8774770	1908	0.8	5.4	2.0	10.4	9.0	7.6	3.4	15.8	39.0	10.0	6.6	21.3	106.8		
TX	Sabine Pass	8770570	1948	0.2	4.9	2.6	9.6	15.2	7.1	6.6	14.9	67.4	9.6	15.2	20.4	217.0		
TX	USCG Freeport	8772447	1958	0.2	7.0	2.0	13.4	13.0	9.1	3.6	18.7	58.0	11.6	58.0	24.2	6.0	Freeport	1
VA	Kiptopeke	8632200	1954	9.6	3.6	20.4	7.1	46.2	5.7	36.0	12.4	140.4	8.2	60.2	17.9	336.6		
VA	Lewisetta	8635750	1951	14.0	4.9	48.8	9.6	162.2	7.1	87.6	14.9	386.0	9.6	139.8	20.4	531.6		
VA	Sewells Point	8638610	1974	9.0	4.5	27.0	8.8	64.4	6.7	39.2	14.1	181.6	9.1	70.8	19.6	389.4		
VA	Wachapreague	8631044	1927	5.0	3.6	11.0	7.1	20.6	5.7	16.0	12.4	58.2	8.2	25.4	17.9	154.4	Kiptopeke	35
VA	Windmill Point	8636580		7.8	4.9	27.6	9.6	95.2	7.1	54.0	14.9	303.8	9.6	95.0	20.4	500.2	Lewisetta	28

Sea-level rise projections courtesy of Climate Central.

DATA SOURCE: CLIMATE CENTRAL N.D.

Figure 1.



Linear trends in sea-level change (in mmyr^{-1}) due to the thermosteric effect during the period 1955 to 2003. Note the large spatial variability in the sea-level change. (From Ishii *et al.* 2006)

Figure source: Milne 2008