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ARTICLE

Key beliefs and attitudes for sea-level rise policy

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ABSTRACT

This article reviews key measures of public opinion on sea-level rise (SLR): beliefs, attitudes, issue prioritization, and policy support. To do so, we first assess the influence of SLR beliefs and attitudes on issue prioritization and policy support using state-level data. Then, we compare the state findings to other surveys conducted in a hot spot of rising coastal waters, the U.S. Mid-Atlantic, to better understand the landscape of public opinion. Our findings indicate that, as in studies of climate change public opinion, belief certainty that SLR is happening and attitudes about its consequences significantly influence issue prioritization and policy support. Compared to climate change, SLR demonstrates less salience, but is similarly a low public priority. Nevertheless, the public supports governmental policies that address the issue, preferring strategies that discourage new construction in high risk areas and employ "soft" protection through natural barriers. Among the least popular approaches are those that implement hard barriers to defend against encroaching seas. Communication programs and public consultation by governments can benefit from the use of survey data to support evidence-based decision-making.

KEYWORDS

adaptation; Mid-Atlantic; policy; public opinion; sea-level rise; surveys

Introduction

Even as U.S. coastal flooding events are reaching higher elevations, making greater incursions inland, and increasing in frequency and duration due to sea-level rise (SLR; Sweet, Park, Marra, Zervas, and Gill 2014), surveys of public risk perceptions and preferences for policy responses have lagged behind those on the broader issue of climate change (Akerlof, Covi, and Rohring 2017). A search of Cornell University's Roper Center's iPoll database yielded 28 national survey questions on SLR between 1997 and 2016. During that same period, almost 3,400 questions appear in the database under global warming or climate change. As a result, understanding of public opinion for the purpose of informing communication strategies and policy decisions on SLR remains comparatively underdeveloped. Regional and state surveys from an area of high SLR risk—the U.S. Mid-Atlantic coast—offer a novel resource

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Supplemental data for this article is available online at here.

for this purpose that are less likely to be captured in polling databases or the academic literature. The Mid-Atlantic region is of particular import for SLR communication and policy because it faces higher projected rates of relative SLR than the global average, ~0.30–0.49 meters by 2100 even in a moderate scenario (Sweet et al. 2017). Waters have been rising about 0.10–0.20 cm a year along the East Coast, but in the Mid-Atlantic, the combination of higher seas with sinking lands, termed subsidence, doubles the relative SLR.

Given the gap in public opinion research regarding SLR and the opportunity to leverage regional and state surveys from the Mid-Atlantic region, we pose two research questions:

> RQ_1: How do public beliefs and attitudes regarding SLR influence issue prioritization and policy support?
>
> RQ_2: What is the status of SLR public beliefs, attitudes, issue prioritization, and policy support across different areas of the Mid-Atlantic?

We answer these research questions using two analyses. First, we employ Maryland state survey data (Akerlof and Maibach 2014) to model the relationship between SLR beliefs, attitudes, issue prioritization, and policy support (Study 1). Then we compare Maryland's survey results with these beliefs and attitudes more broadly across the Mid-Atlantic region (Study 2). We present county-level results from Anne Arundel, Maryland (Akerlof 2012); metropolitan area findings from a survey in Hampton Roads, Virginia (Yusuf et al. 2017); and state-level data from Delaware (Responsive Management 2014). Each of these areas faces unique impacts from SLR (see Box 1). The article concludes with a discussion of implications for research and coastal management practices.

Box 1. Impacts from SLR in the study areas

State of Maryland. State estimates project approximately 1.4 feet of relative SLR by 2050 and 3.7 feet by 2100 with the potential for as high as 2.1 feet by 2050 and 5.87 feet by 2100 (Boesch et al. 2013). More than 172,000 acres of Maryland are at elevations less than 3.3 feet above high tide, placing it among the top 10 states at risk in the nation (Strauss, Ziemlinski, Weiss, and Overpeck 2012).

Anne Arundel, Maryland. More than 530 miles of this county's shoreline border Chesapeake Bay. In 2003, Hurricane Isabel left the historic state capital of Annapolis more than knee-deep in water—5.7 feet above the high tide line at the U.S. Naval Academy (Strauss et al. 2014b)—while the county suffered flooding, erosion and structural damage (Hennessee and Halka 2005Marti). Under moderate rates of relative SLR, almost 2,000 acres of the county could be submerged by 2050, with the number doubling by 2100 (Batten 2012).

State of Delaware. SLR is expected to cause record-breaking coastal flooding in the state before 2035 (Strauss et al. 2014a). With more than 37,000 acres at less than 3.3 feet above high tide, Delaware is among the top 15 states at risk (Strauss et al. 2012).

Hampton Roads, Virginia. This urban region in southeastern Virginia is home to 1.7 million people living in 17 municipalities and is economically dependent on the Navy, shipbuilding, ports and tourism—all coastal-related industries. A study by RTI International (Van Houtven, Depro, Lapidus, Allpress, and Lord 2016) found that SLR will increase the cost of damages due to flooding by up to $100 million by 2060. Nuisance flooding is already affecting transportation and commerce around the region, with 10 full days of flooding on average each year (Ezer and Atkinson 2014). Projections of regional transportation impacts for 2100 show 10% of major roadways will regularly flood at high tide and 65% in a 100 year storm event (Sadler et al. 2017).

Employing survey data in evidence-based communication and decision-making

Public communication and policy support are intertwined: insufficient problem awareness, lack of policy support, and slow institutional and stakeholder learning are examples of "dynamically linked" barriers to adaptation that require interventions to break the cycle (Eisenack et al. 2014). Opinion surveys can serve as a form of public consultation by governments and other organizations to take the "pulse" of residents in weighing policy approaches, increasing the potential for more democratic governance that is deferential to mass preferences as opposed to powerful constituencies (Shapiro 2011).

Few nationally representative studies on SLR adaptation exist. In 2013, a Stanford University study of U.S. adults found that the public supports taking actions now (82%) to adapt to SLR (GfK Custom Research North America 2013). Limiting new building (51%) and stricter building codes (62%) were the most popular approaches. Other researchers have focused on public responses to SLR in specific locations, or as a result of a catastrophic event. Treuer, Broad, and Meyer (2018) exposed study participants from South Florida to a computer simulation illustrating SLR effects in 35 years. They found that more than 70% were supportive of raising taxes for adaptation at three time periods within the simulation—2016, 2030, and 2050—and that willingness to move increased as effects become more severe. Song and Peng (2017) modeled the factors associated with willingness to migrate by residents of Panama City and Panama City Beach, Florida, and found SLR awareness and beliefs about cost damages to be predictive. Working with communities post-Hurricane Sandy, a number of authors have assessed the factors related to relocation decisions (Bukvic and Owen 2017; Bukvic, Smith, and Zhang 2015; Bukvic, Zhu, Lavoie, and Becker 2018) and the types of communication that promote adaptation strategies to prepare for future storms (Wong-Parodi, Fischhoff, and Strauss 2018).

The surveys that underpin our analyses—state-wide surveys in Maryland and Delaware; a regional survey in Hampton Roads, Virginia; and a county-level survey in Anne Arundel, Maryland—were conducted to inform decision-making on SLR policies. All but one were fielded in collaboration with state or regional units of the National Oceanic and Atmospheric Administration's National Sea Grant College Program through its initiatives on resilient coastal communities and economies (see examples of survey use, Supplementary Materials, Box S1).

The use of audience research in developing communication programs for the public has been linked to higher rates of effectiveness (Merzel and D'Afflitti 2003; Noar 2006). As a result, recommendations for climate change communication often suggest utilizing this approach within the framework of a social marketing-based campaign strategy (Bostrom, Böhm, and O'Connor 2013). Surveys are one of the most common methods of this formative research (Atkin and Freimuth 2013).

But which questions to ask? Most of the extant SLR surveys have been informed by the design of academic climate change polls, but—to our knowledge—no one has established the applicability of their underlying theoretical models to the issue. SLR is a multi-causal phenomenon. In the Mid-Atlantic, it results from subsidence due to continuing adjustments in the Earth's surface caused by the retreat of the glaciers after the last ice age ($\sim 1.3 \pm 0.4$ mm/year) and groundwater loss (0.3–1.3 mm/year), as well as

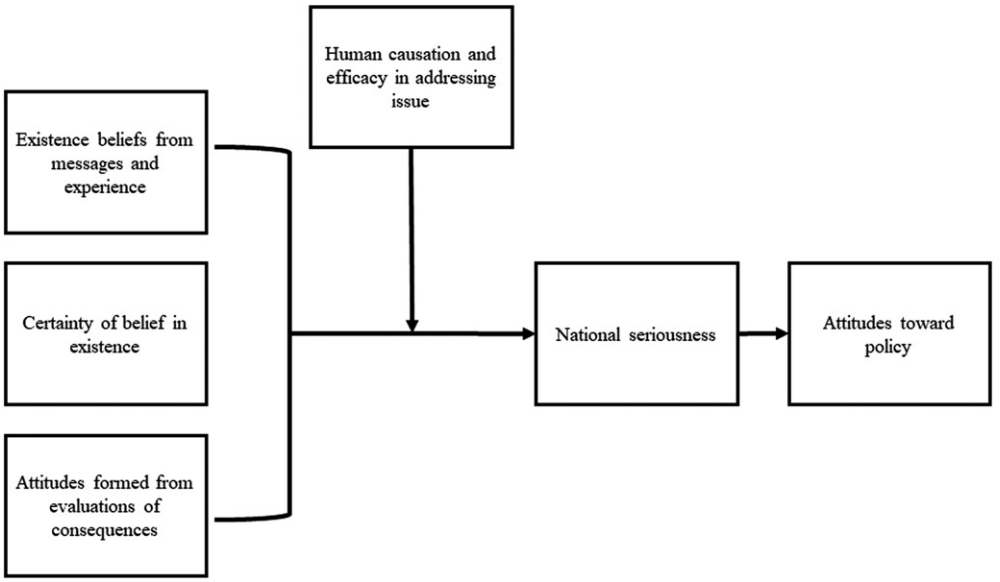

Figure 1. The original ACE (Attitude, Certainty, and Existence beliefs) model for global warming policy support.

from anthropogenic warming ($\sim 1.7 \pm 0.2$ mm/yr) (Miller, Kopp, Horton, Browning, and Kemp 2013). Between Virginia and South Carolina, total subsidence rates can double due to groundwater withdrawals (Karegar, Dixon, and Engelhart 2016). In Study 1, we explore whether the same "key" attitudes and beliefs found in climate change public opinion research are applicable to SLR, exploring the role that they play in public prioritization of the issue and policy support. In Study 2, we compare the Maryland survey results to findings from other SLR studies in the U.S. Mid-Atlantic to evaluate their similarity.

Important factors in climate change—and SLR?—issue prioritization and support

In 2006, Stanford University's Krosnick and colleagues conducted a study on the beliefs and attitudes that predict global warming national seriousness attitudes and policy support. They identified five attitudes and beliefs: (1) belief in the existence of global warming, derived from messages and experience; (2) certainty in those beliefs; (3) attitudes about the consequences of global warming; (4) beliefs about human causation; and 5) efficacy in addressing global warming (Krosnick et al. 2006). As shown in Figure 1, their original ACE (Attitude, Certainty, and Existence beliefs) model posited that the first three—belief in global warming's existence, certainty of its existence, and attitudes about its effects—contributed to perceptions of national seriousness through a five-way interaction with human causation and efficacy. National seriousness, in turn, was hypothesized to influence attitudes towards policy.

Using this work as a foundation, researchers at the Yale Program on Climate Change Communication and George Mason Center for Climate Change Communication

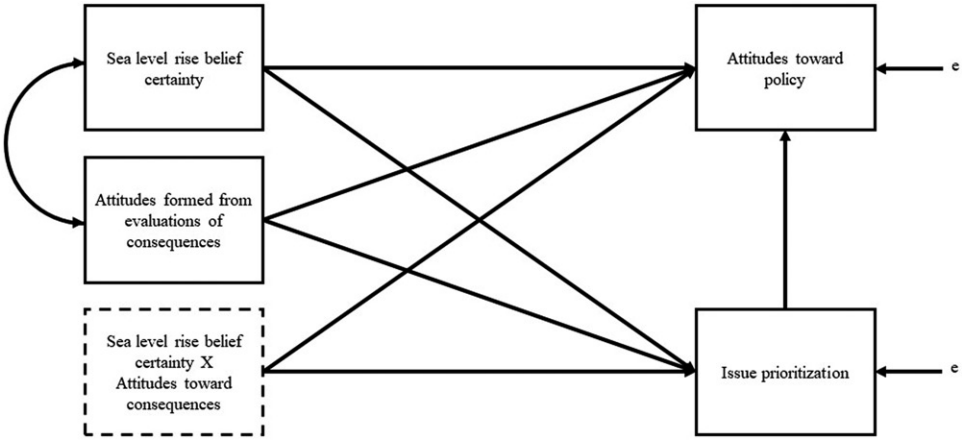

Figure 2. A model of SLR issue prioritization and policy support.

subsequently captured the interaction between certainty with belief in global warming by combining the two variables and derived what they term the "four key global warming beliefs": (1) certainty that climate change is real; (2) that it is human-caused; (3) that its effects are harmful; and 4) that people collectively can successfully take action (Roser-Renouf and Maibach 2018). In their 10 years of analyses of national survey data, they found that these beliefs are consistently correlated with worry, issue personal importance, communication with others, policy support, contacting representatives on climate policy, and consumer decisions (Ding, Maibach, Zhao, Roser-Renouf, and Leiserowitz 2011; Roser-Renouf and Maibach 2018). This framework has been widely utilized in government climate communication strategies, such as by the National Park Service (Akerlof, Bruff, and Witte 2011, 61).

In Study 1, we extend the ACE model by adapting it specifically to SLR (Figure 2). We combine certainty and belief in the existence of SLR into "belief certainty," consistent with the approach taken by the Yale and George Mason researchers (Ding et al. 2011). Furthermore, in recognition that a large cause of SLR in the Mid-Atlantic is not anthropogenic (instead due to post-glacial adjustments in the Earth's surface), we do not include human causation in the model. While we know efficacy to be an important factor in risk responses (Rogers 1975; Witte 1992), the effectiveness and socioeconomic suitability of specific SLR adaptation strategies is highly variable dependent on hyper-local factors (Barnett et al. 2014), which cannot be generalized to the state level. Hence, we also do not include efficacy.

The original ACE model regressed policy attitudes only on national seriousness and did not test whether core beliefs and attitudes regarding climate change also had direct effects on attitudes toward policy. Building on the findings of George Mason and Yale researchers that the climate change belief certainty and attitudes about harm directly affect policy support (Ding et al. 2011), we also include a direct effect on policy attitudes. Our model, summarized in Figure 2, posits that SLR belief certainty, attitudes about consequences, and their interaction have direct and indirect effects on SLR policy attitudes, e.g. policy support. An interaction between belief certainty and attitudes about consequences is hypothesized based on Krosnick et al.'s findings. We test the adapted

model using data from a statewide survey of Maryland residents conducted in 2014 to answer the first research question:

> RQ_1: How do public beliefs and attitudes regarding SLR influence issue prioritization and policy support?

Public opinion and policy support for SLR adaptation

In Study 2 we compare the survey findings from Maryland with those from three other Mid-Atlantic studies conducted between 2012 and 2016 to assess how consistently SLR public beliefs, attitudes, issue prioritization, and policy support manifest in the region. One of the goals in engaging the public on SLR is to inform policy choices (Akerlof et al. 2017). The three primary response categories to SLR are retreat, accommodation, and protection (IPCC Coastal Zone Management Subgroup 1990). In retreat, communities leave a coastal zone because of the severity of impacts. In accommodation, communities implement strategies to remain in the coastal zone, but become more resilient to the effects of flooding, such as raising the base floor elevation of buildings. Finally, protection employs either hard or soft barriers, such as sea walls and dikes, or wetlands and sand dunes.

The types of decisions that communities can make regarding the built environment can be categorized in various ways (Grannis 2011). Planners and policymakers address questions such as which strategy is most suited to the natural and built environment, which policy tool (or toolkit) suits the problem, and finally, if it requires funding, who pays. The multi-factorial context, and innumerable permutations of options, make asking survey questions about preferred approaches difficult. In Study 2, we assess the landscape of these survey results in the Mid-Atlantic, compared to Maryland, to answer the second research question:

> RQ_2: What is the status of SLR public beliefs, attitudes, issue prioritization, and policy support across different areas of the Mid-Atlantic?

Study 1 methods

Data collection and treatment

Data used to model SLR issue prioritization and support were obtained from a mail survey conducted by George Mason University's Center for Climate Change Communication in partnership with the Maryland Department of Health and Mental Hygiene. The study explored Marylanders' views on public health, energy, and the environment. The survey was fielded from March 17 to June 10, 2014 with a sample size of 2,035 and response rate of 35%. Respondents who did not provide regional, gender, age or education level data were dropped from the data set. The unweighted sample margin of error is ± 2 percentage points at the 95% confidence interval for the state.

The survey was mailed to 6,401 households in the state of Maryland, randomly selected from within each of four regions of the state from Survey Sampling International household address databases, based primarily on U.S. Postal Service delivery route information. Sampling was done at the regional level to ensure the final data was generalizable to these distinctly different geographic and cultural areas of the state.

Table 1. Survey sample demographic and political ideology characteristics compared to American Community Survey (ACS) and Gallup estimates (Gallup, 2014; U.S. Census Bureau, 2015a, 2015b).

		Survey	ACS, 5 year estimates, 2014	Δ
Gender	Female	61	52	9
Age	18 to 24	2	10	−8
	25 to 34	12	14	−2
	35 to 44	16	13	3
	45 to 54	20	15	5
	55 to 64	24	13	11
	65 to 74	17	7	10
	75 to 84	8	4	4
	85 years and over	3	2	1
Education	Less than high school	2	11	−9
	High school or GED	38	43	−5
	Associate's degree	7	11	−4
	Bachelor's degree	25	19	6
	Advanced degree beyond bachelor's degree	28	15	13
		Survey	Gallup	Δ
Political ideology	Conservative	27	31	−4
	Moderate	41	34	7
	Liberal	32	29	3

(During the analysis, the data was weighted to reflect statewide population proportions.) Each household was sent up to four mailings: an announcement letter introducing the survey (March 17), a copy of the survey with a $2 bill as a thank you (March 24), a reminder postcard (April 7), and a follow-up survey (April 22). The methodology is based on a commonly used mail survey technique developed by Dillman and colleagues (2009). Sample bias is characterized in Table 1. Missing data treatment is described in Supplementary Materials, Box S2. Variables used in the analysis are described next. Their descriptive statistics are provided in Table 2.

Observed exogenous variables: Beliefs and attitudes

SLR belief certainty: The measure consists of two questions combined: Do you think that SLR is currently happening along Maryland's coastlines? If you answered either yes or no, how sure are you?

Attitudes toward SLR consequences: Ten dichotomous indicators are summed to measure the degree of concern over the effects of SLR impacts based on the question: Which impacts from SLR in Maryland, if any, are you most concerned about?

- private property damage or loss
- damage or loss of public infrastructure, like roads
- habitat loss
- shoreline erosion and loss of land
- increased frequency and severity of flooding
- permanently flooded areas (inundation)
- higher storm surge
- contamination of freshwater wells
- problems with stormwater drainage
- loss or damage of sewage and septic systems

Table 2. Variables and descriptive statistics.

Variables	*M*	*SD*
Female *[Yes (1); No (0)]*	0.61	0.49
Age *[18 to 24 years (1) to 85 years and over (8)]*	4.46	1.62
Education *[Less than high school (1) to advanced degree beyond a bachelor's degree (5)]*	3.39	1.3
Income *[Less than $10,000 (1) to $150,000 or more (9)]*	6.27	2.25
Political ideology *[Very conservative (1) to very liberal (5)]*	3.07	1.04
Attitudes toward consequences *[Total number of impacts of most concern (0-10)]*	4.25	3.45
SLR belief certainty *[Extremely sure SLR is not happening (1) to extremely sure SLR is happening (9)]*	5.91	1.58
SLR issue prioritization *[Not a priority (1) to very high (5)]*	3.58	1.11
Attitudes toward SLR policy *[Average of 5 measures, strongly oppose (1) to strongly support (5)]*	3.69	0.84
$n = 1{,}891$		

Control variables: Gender, age, education, income, and political ideology served as controls in the analysis.

Observed endogenous variables: Issue prioritization and policy support

Issue prioritization: How much of a priority should protecting Maryland's coastal areas from SLR be for Maryland's General Assembly and the Governor?

Attitudes toward policy: Five SLR policy support measures are averaged to represent mean policy support: How much do you support or oppose the following approaches to dealing with SLR in Maryland?

- Long-range planning that takes SLR into account
- Changes to regulations, such as zoning laws and increased "set back" distances to discourage building in areas likely to be affected by SLR
- Use of government spending to buy coastal lands to maintain and restore natural areas as buffers against SLR and storms
- Use of government spending to build walls and other structural barriers along the shore to hold back coastal waters
- Providing tax incentives to property owners to take actions that reduce flood risk

Statistical analyses

We standardized all variables and created the interaction term between SLR belief certainty and attitudes toward consequences by multiplying the z-scores for those variables ($n = 1{,}891$). A weighted covariance matrix was used to conduct a path analysis of the proposed model using IBM SPSS AMOS 25 (Supplementary Materials, Table S1). We bootstrapped the analysis using 1,000 samples in order to generate estimates and significance values for the direct, indirect, and total effects.

Study 1 results

Survey measures

Most Marylanders (53%) said they were not sure whether SLR was currently occurring along the state's coasts. Only 18% were very or extremely sure it was happening.

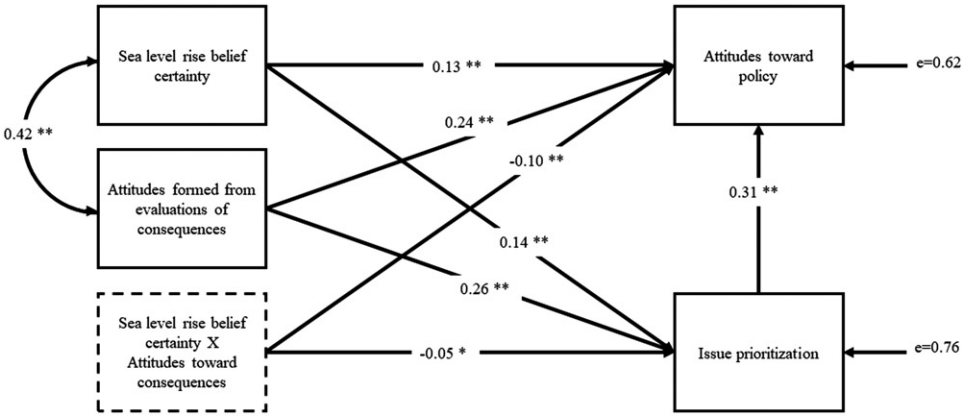

Figure 3. Path analysis with standardized coefficients.

Though few respondents said they were not concerned about any impacts (8%), shoreline erosion and loss of land were the only impacts of concern to a majority (54%). Attitudes toward five general SLR adaptation policies were generally supportive, ranging from 48% to 67%. Yet, only a slim majority (55%) said that protecting Maryland's coastal areas from SLR should be a high or very high priority for the governor and general assembly.

Path analysis

The results of the path analysis with standardized coefficients are displayed in Figure 3 (see final correlations and coefficients, Supplementary Materials, Table S2). All pathways posited by our model (Figure 2) were statistically significant.

Model fit is good (RMSEA = 0.017; CFI = 0.998), and the chi-square value is not statistically significant ($\chi^2 = 15.70$, df = 10, $p = 0.11$). The model explains 17% of the variance in issue prioritization and 36% of the variance in SLR policy support. As demonstrated in Figure 3 and Table 3, SLR belief certainty, attitudes about its consequences, and their interaction term have direct effects on issue prioritization. Table 3 also shows that these variables have both direct and indirect effects on SLR policy support. Issue prioritization similarly has direct effects on policy support. The total effect sizes of the individual variables, ranging in absolute value from 0.12 for the interaction term to 0.32 for attitudes toward SLR consequences, are relatively small (Cohen 1988). Most of the effect on policy support is through the direct effects of the variables (absolute values 0.10 to 0.31), as opposed to indirect effects through issue prioritization (absolute values 0.01 to 0.08).

For coastal managers looking to interpret the coefficients of each pathway, positive and statistically significant coefficients, such as those for belief certainty and impact attitudes, suggest opportunities to increase issue prioritization and policy support by elevating public opinion in these areas through outreach and engagement. Generally, the larger the standardized coefficient, the more influence of the variable on the policy measure. The negative value of the interaction coefficients reflects that as both belief certainty and attitudes rise among the public, the relative size of the increase in issue prioritization and policy support declines (Figures 4 and 5).

Table 3. Direct, indirect, and total effects on attitude toward SLR policy (e.g. policy support) (standardized bootstrapped results).

	SLR belief certainty	Attitudes-consequences	Certainty X Attitudes-consequences	Issue prioritization
Direct effects	0.13**	0.24**	−0.10**	0.31**
Indirect effects	0.04**	0.08**	−0.01*	
Total effects	0.18**	0.32**	−0.12**	0.31**

***$p < .001$; **$p < .01$; *$p < .05$.

To conclude, the results of Study 1 demonstrate that, as in the case of climate change public opinion, belief certainty that SLR is happening and attitudes about its impacts significantly relate to issue prioritization and policy support. However, they explain less than half of policy support (36%) and an even smaller percentage of issue prioritization (17%). This suggests they represent just one dimension of the wider socio-political context influencing public opinions on this policy area. These results underscore the need to better understand public opinion regarding SLR, particularly in highly vulnerable regions such as the Mid-Atlantic. In Study 2, we explore this landscape of SLR public opinion.

Study 2 methods

In the second analysis, we compare the 2014 Maryland state survey findings to three additional studies of SLR public opinion conducted in Delaware, Virginia, and Maryland. We focus on the variables described in the model tested in Study 1: certainty of belief that SLR is happening, attitudes toward its consequences, issue prioritization, and attitudes toward policy (e.g., policy support). While the questions are not phrased identically across the surveys, they can be used to identify patterns across the data sets.

Extreme weather events may influence public opinion, at least for short durations (Konisky, Hughes, and Kaylor 2016). During the years in which the surveys were fielded, all areas experienced coastal flood events, but no hurricane activity (Atkinson 2019; NOAA National Centers for Environmental Information n.d.).

State of Delaware

The state of Delaware and the Delaware Sea Grant College Program conducted a telephone survey of both landlines and cell phones in August 2014, obtaining a total of 1,508 completed interviews (Responsive Management 2014). The sample margin of error is ± 2.5 percentage points at a 95% confidence level.

Hampton Roads, Virginia

A metropolitan area study is reported from Hampton Roads (in southeastern Virginia). Old Dominion University researchers conducted an online survey of 1,633 residents of the seven Hampton Roads cities from May 1, 2016 to July 1, 2016 (Yusuf et al. 2017). While a convenience sample, demographic characteristics compare favorably with 2010 Census data for the MSA (Tables S3–S4, Supplementary Materials). This survey of Hampton Roads residents' perceptions of SLR and flooding adaptation included

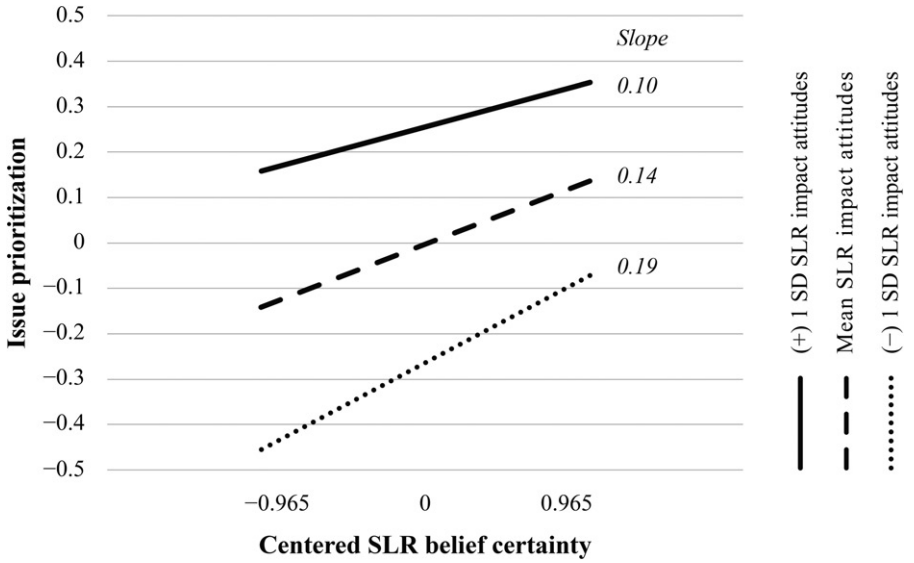

Figure 4. The interaction effect of SLR belief certainty per one standard deviation in impact attitudes on issue prioritization.

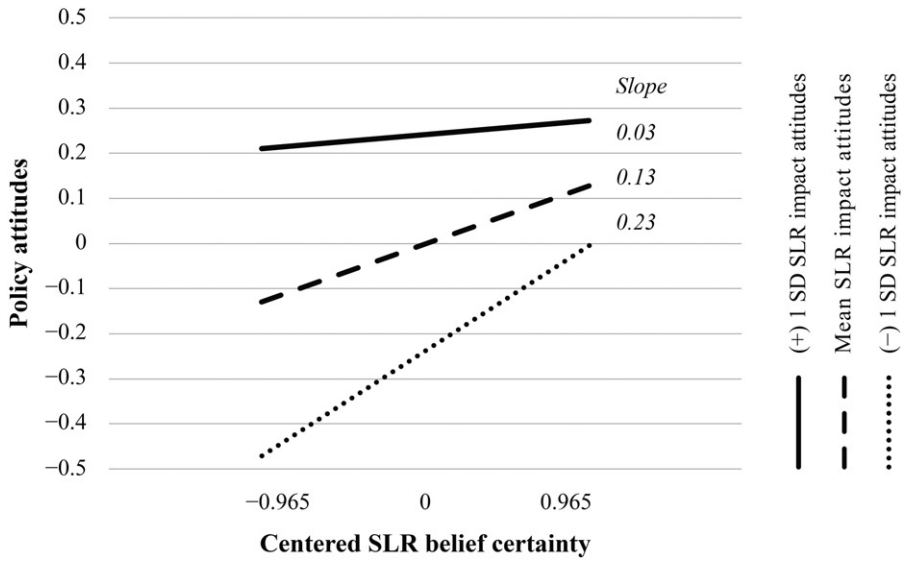

Figure 5. The interaction effect of SLR belief certainty per one standard deviation in impact attitudes on policy attitudes (e.g. support).

questions about SLR risk perceptions and policies similar to questions asked in the Maryland survey described in Study 1.

Anne Arundel, Maryland

Funded by NOAA's Mid-Atlantic Regional Sea Grant Consortium, a mail survey of randomly selected Anne Arundel County residents was fielded between March 28 and June

Table 4. [Maryland] (a) Do you think that sea-level rise is currently happening along Maryland's coastlines? If you answered either yes or no, how sure are you? (b) Do you think that climate change is happening? If you answered either yes or no, how sure are you?

	3/17-6/10/2014 SLR	3/17-6/10/2014 climate change
Extremely/very sure is not happening	2%	4%
Somewhat/not at all sure is not happening	6%	6%
Don't know	53%	13%
Somewhat/not at all sure is happening	21%	32%
Extremely/very sure is happening	18%	44%
n	2,012	1,995

Table 5. [Delaware] How convinced are you that [sea levels are rising/climate change is happening]?

	8/2014 SLR	8/2014 climate change
Completely convinced	39%	46%
Mostly convinced	31%	32%
Not so convinced	17%	13%
Not at all convinced	9%	7%
Don't know	5%	1%
n	1,508	1,508

19, 2012 and resulted in completed surveys from 378 adult residents age 18 years or older (Akerlof 2012). The margin of error is of ± 5 percentage points within a 95% probability.

Study 2 results

Certainty of belief that SLR is occurring

The Maryland and Delaware surveys asked whether respondents understood that SLR is currently occurring, and the extent that they were certain. Larger percentages of residents from both states said they were sure that climate change was occurring than that sea levels are rising. In Maryland, 18% said they were very or completely sure that sea rise was happening along the state's coastlines, and 44% said that they were very or completely sure that climate change is happening (Table 4). In Delaware, 70% said they were mostly or completely convinced that SLR is happening, and 78% that climate change is happening (Table 5).

More than half of Marylanders (53%) said that they did not know whether SLR was currently occurring along Maryland's coastlines. Notably, the Maryland question about whether SLR is happening refers to a specific place, whereas the Delaware question asks generally whether the phenomena is occurring, abstract of any location. The difference between the two sets of survey results may be due to the degree of specificity; this would correspond to other findings that climate change impacts are perceived as geographically distant (Leiserowitz 2005).

Attitudes toward consequences of SLR

While the state surveys phrased questions about likely impacts from SLR differently, respondents indicated in both state studies that the largest effects will be felt upon coastal shorelines (Maryland, shoreline erosion and loss of land, 54%; Delaware,

Table 6. [Maryland] Which impacts from sea-level rise in Maryland, if any, are you most concerned about? (Please check ALL THAT APPLY).

	3/17-6/10/2014
Shoreline erosion and loss of land	54%
Habitat loss	47%
Private property damage or loss	44%
Damage or loss of public infrastructure, like roads	42%
Contamination of freshwater wells	42%
Increased frequency and severity of flooding	40%
Loss or damage of sewage and septic systems	37%
Higher storm surge	36%
Problems with stormwater drainage	36%
Permanently flooded areas (inundation)	28%
Don't know	18%
Not concerned about any impacts	8%
n	2,035

Table 7. [Delaware] How serious a threat do you think SLR is to … *(1-Very serious to 4-Not at all serious, Don't know)*.

	8/2014 very serious
Delaware beaches	57%
Oceanfront cities and towns in Delaware	56%
Marsh and wetlands in Delaware	47%
Riverfront cities and towns in Delaware	43%
Delaware's public works systems, such as public buildings, roads, and sewer systems	34%
Delaware's wildlife populations	33%
Delaware's economy	30%
Outdoor recreation in Delaware	29%
Your local community	22%
You personally	18%
Your property	16%
Your family	16%
n	1,508

Table 8. [Hampton Roads, VA] Which [infrastructure/quality of life] impacts from SLR in Hampton Roads, if any, are you most concerned about? (Please choose ALL THAT APPLY).

	5/1-7/1/2016
Increased frequency and severity of flooding	79%
Private property damage or loss	75%
Problems with stormwater drainage	70%
Shoreline erosion and loss of land	69%
Damage or loss of public infrastructure, like roads	64%
Higher storm surge	63%
Habitat loss	57%
Loss or damage of sewage and septic systems	55%
Permanently flooded areas (inundation)	53%
Contamination of freshwater wells	51%
n	1,633

beaches, 57%) (Tables 6 and 7). Effects on wildlife and species habitats ranked as high concern in both states as well (MD, habitat loss, 47%; DE, marsh and wetlands, 47%), followed by concern about public infrastructure (MD, damage or loss of public infrastructure, 42%; DE, Delaware's public works, 34%). As shown in Table 8, Hampton Roads residents showed the most concern about increased frequency and severity of

Table 9. [Maryland] Maryland's state and local governments have various options for dealing with sea-level rise. How much do you support or oppose the following approaches to dealing with sea-level rise in Maryland? *(1-Strongly oppose to 5-Strongly support)*.

	3/17-6/10/2014
	Somewhat/strongly support
Changes to regulations, such as zoning laws and increased "set back" distances to discourage building in areas likely to be affected by sea-level rise	67%
Long-range planning that takes sea-level rise into account	65%
Providing tax incentives to property owners to take actions that reduce flood risk	56%
Use of government spending to buy coastal lands to maintain and restore natural areas as buffers against sea-level rise and storms	55%
Use of government spending to build walls and other structural barriers along the shore to hold back coastal waters	48%
n	2,035

Table 10. [Delaware] Do you support or oppose [....] to address sea-level rise in Delaware or reduce its impacts? *(1-Strongly support to 5-Strongly oppose, Don't know)*.

	8/2014 Moderately/strongly support
Changing building codes and regulations to reduce risk in flood prone areas	85%
Avoiding building new structures in areas at risk from SLR	77%
Increasing funding for research	72%
Elevating buildings in areas at risk from SLR using private funding	71%
Building dikes, seawalls, and bulkheads to keep water back	65%
Allowing beaches and wetlands to naturally migrate inland	64%
Elevating the land surface in areas at risk from SLR	63%
Elevating buildings in areas at risk from SLR using government funds	52%
Purchasing of acquiring land and open space at risk from SLR from willing land sellers using government funds	46%
Purchasing or buying out frequently flooded properties using government funds	42%
n	1,508

flooding (79%), private property damage and loss (75%), problems with stormwater drainage (70%), shoreline erosion and loss of land (69%), and damage or loss of public infrastructure, like roads (64%).

Issue prioritization

The state surveys—Maryland and Delaware—found that like climate change, SLR is at the bottom of the list as an issue priority for the public, either as a local or national issue. Residents say both SLR and climate change are high priorities or concerns—but at the same time, they rank most other priorities higher, like jobs and the economy. In Maryland, 55% said that protecting Maryland's coastal areas from SLR should be a high or very high priority for the Governor and General Assembly, and 51% said the same for climate change (Akerlof and Maibach 2014, 20–21). But creating jobs was first at 89%. In Delaware, 78% said that climate change was an issue that somewhat or very concerned them, and 66% said the same of SLR (Responsive Management 2014, 9). The economy topped the list at 96% very or somewhat concerned.

Table 11. [Anne Arundel County, MD] Which of these strategies do you most support?.

(Ranking, respondents selected first choice)		3/28-6/19/2012
Low-density residential areas in the county ($n = 354$)	Maintain and restore natural areas such as wetlands and beaches as buffers against coastal flooding	48%
	Retreat inland over time, restricting new building in areas likely to flood, and moving or abandoning existing structures	32%
	Build walls and other structural barriers along the shore to hold back coastal waters	12%
	Design and retrofit buildings to be more flood resilient, including elevating them and/or the land	8%
Publicly-owned natural areas in the county ($n = 345$)	Maintain beaches and wetlands against rising seas	46%
	Buy adjacent lands to enable natural areas to move inland	34%
	Build walls and other structural barriers along the shore to hold back coastal waters	20%
High-density commercial and residential areas in the county ($n = 354$)	Maintain and restore natural areas such as wetlands and beaches as buffers against coastal flooding	46%
	Retreat inland over time, restricting new building in areas likely to flood, and moving or abandoning existing structure	30%
	Build walls and other structural barriers along the shore to hold back coastal waters	16%
	Design and retrofit buildings to be more flood resilient, including elevating them and/or the land	8%

Table 12. [Hampton Roads, VA] Do you favor, oppose, or neither favor nor oppose? *(1-Strongly oppose to 5-Strongly support)*.

	5/1-7/1/2016
	Somewhat/strongly support
… the government passing laws to reduce the number of new buildings that people and businesses can build on the coast?	78%
… the government building sand dunes to protect roads and buildings?	76%
… the government passing laws saying that if a building near the coast is seriously damaged by flooding or storms, no one can build a new building in that location?	71%
… the government putting new sand on beaches to keep them the same size?	69%
… the government offering money to people and businesses near the coast if they move inland?	52%
… the government building walls like this along shores where damaging flooding is likely to increase in the future because of global warming?	43%
n	1,631

Preferences for adaptation policies

Across the three broad policy categories of SLR protection, accommodation, and retreat, the Mid-Atlantic survey findings generally demonstrated stronger support for retreat and soft protection than hard protection or armoring (Tables 9–12).

Retreat

More than two-thirds of Maryland residents favored increased set-back distances for new buildings (67%) (Table 9). In Delaware, avoiding new building in areas at risk altogether was similarly strongly supported (77%) (Table 10). In Maryland's Anne

Arundel County, retreat—of either buildings or natural areas—was the second most favored approach (for low-density residential areas, 32%; natural areas, 34%; high-density residential and commercial areas, 30%) (Table 11). And in Virginia's Hampton Roads 2016 study, more than three-quarters of the public supported restricting new coastal construction (78% support) (Table 12).

Soft protection—natural barriers

More than half of Marylanders supported government spending to buy coastal lands to maintain and restore natural areas as buffers against SLR and storms (55%). Allowing beaches and wetlands to naturally migrate inland—in effect facilitating current natural buffers—was favored by 64% in Delaware. In Maryland's Anne Arundel County, the strategies most supported across all three types of development—high and low density, and public natural areas—were "soft" barriers like wetlands, beaches, and dunes (46–48%). Increased building of sand dunes to protect roads and buildings (76%) was also strongly favored in Virginia's Hampton Roads 2016 study, as was replenishing sand to maintain the beaches (69%).

Accommodation

In Maryland, the question about accommodation asked about tax incentives to support risk reduction by property owners, which was supported by more than half (56%). In Delaware, elevation of existing buildings—either with private (71%), or government funds (52%)—was supported by majorities. In Maryland's Anne Arundel County, designing and retrofitting buildings to be more resilient, including elevating them or the land was the least preferred of the options (8%). This relatively low percentage of support in comparison to the state measures reflects that participants selected their highest preferred option, as opposed to rating their support for each policy individually. It may also signify the lack of appeal and/or feasibility of options such as elevation.

Hard protection—armoring

Coastal armoring was the least supported of five policy options by Marylanders as a whole, though the question also stipulated that it would be paid for with government spending. Less than half (48%) supported the use of government funds to build walls and other structural barriers along the shore to hold back coastal waters. In Delaware, building dikes, seawalls, and bulkheads to keep water back ranked in the middle of the surveyed policy options at 65%, less popular than promoting risk reduction through building codes (85%), but more popular than buying out flooded properties (42%). In Anne Arundel County, hard measures—building walls and other structural barriers—were roughly as unpopular as accommodation (12–20%, compared to 8–20%). And in Virginia's Hampton Roads, the least favored of six policy options was government building of walls along shorelines (43%).

Table 13. [Anne Arundel County, MD] Local governments have different types of policy tools they can use. How much do you support or oppose their use of these types to limit the impacts of coastal flooding due to sea-level rise? *(1-Strongly support to 5-Strongly oppose, Don't know)*.

	3/28-6/19/2012
	Somewhat/strongly support
Long-range planning that takes sea-level rise into account ($n = 375$)	82%
Changes to regulations, such as zoning laws in coastal areas ($n = 374$)	72%
Providing tax incentives to property owners to take actions that reduce flood risk ($n = 375$)	68%
Use of government spending, such as buying coastal lands and new infrastructure ($n = 373$)	51%

Policy tools

Governments have a number of regulatory and financial tools they can use to reduce SLR risk. In Maryland and Delaware, the most popular tools were changing building codes and implementing new regulations to reduce risk (67%/85%, Tables 9 and 10). Long-range planning that accounts for SLR was also popular among Marylanders (65%). Respondents in Maryland's Anne Arundel County similarly voiced the strongest support for long-term planning that takes SLR into account (82%, somewhat/strongly support, Table 13), followed by changes in regulations, such as zoning laws (72%, somewhat/strongly support). The policy tools that included "using government funds" were least supported of those included on the list of both Maryland and Delaware options (Tables 9 and 10).

Discussion

In this article, we asked two research questions: 1) how do public beliefs and attitudes regarding SLR influence issue prioritization and policy support? and, 2) compared to Maryland, what is the status of SLR public beliefs, attitudes, issue prioritization, and policy support across different areas of the Mid-Atlantic? Our findings, consistent with studies of climate change public opinion, suggest SLR belief certainty and attitudes about its impacts significantly relate to issue prioritization and policy support. These results highlight the importance of understanding these key beliefs and attitudes about SLR in support of public communication initiatives. SLR is often described as one of the more visible manifestations of climate change (Sea level rise, 2012). Even so, our conclusion from reviewing four public opinion surveys conducted in Virginia, Maryland, and Delaware is that SLR is a less salient public concern compared to climate change. And—in what may seem like a further contradiction—at the same time there is general support for adaptation strategies and policies.

In Study 1, we extended the ACE model developed in the context of climate change (Krosnick et al. 2006) and applied it specifically to SLR. The results of our path analysis suggest that the ACE model similarly holds for SLR, demonstrating the importance of belief certainty and attitudes toward impacts for issue prioritization and policy support. Public communication regarding the local manifestation and impacts of SLR is therefore vital and should be considered a critical component of the policy decision-making and implementation toolbox for coastal managers.

This is particularly true, because the Mid-Atlantic survey findings suggest that SLR is a less salient concern to the public than climate change, even in coastal areas at high

risk. While collectively the surveys portray audiences that are not highly certain about SLR, counterintuitively, Mid-Atlantic residents also generally support measures to address the problem. Policies favoring softer natural approaches or retreat through promotion of construction in lower-risk areas tend to rank higher than building hard coastal barriers against encroaching waters. The use of government funding to implement these policies, however, may depress public support. How are coastal managers to interpret support for policies to address an issue on which there appears to be uncertainty?

Potential for change in policy support with change in attitudes and beliefs

The time period covered by the surveys—2012 to 2016—is too short to capture longer term trends in public opinion, but it is notable that there were few differences in responses between an earlier version of the Delaware survey that was fielded in 2009 (Responsive Management 2010) and the study reported here that was conducted five years later. One reading of this is that public understanding of SLR and policy support are likely to remain stable, if at low levels of salience.

On the other hand, within the survey literature, there is significant evidence that some fraction of the public has no prior opinion on questions asked in surveys, but feels impelled to provide an answer, and indeed may not be given the option to state "no opinion" (Krosnick et al. 2002). These reported beliefs and attitudes may either be randomly chosen by the respondent or selected based on cues from the question format. As such, they are not firmly held, and likely to change.

Data collected before and after a community deliberative event in Anne Arundel County (associated with one survey reported in this article), demonstrated significant shifts in policy support following just one daylong informational session (Akerlof 2012), with preferences for adaptation strategies revealing a greater comprehension of the factors involved under different development conditions. Similarly, a daylong engagement event in Hampton Roads resulted in changes in perceptions about individual efficacy and willingness to pay more in taxes or fees to help the community become more resilient to flooding (Yusuf, St. John III, Covi, and Nicula 2018). In these cases, the deliberative events supported discussion of adaptation actions and influenced preferences. But examples of negative responses to deliberation within the public sphere—and subsequent legislation inspired by the perception that governmental adaptation actions will threaten coastal property values—are also not uncommon, such as in North Carolina (North Carolina 2012). This suggests the importance of public communication efforts in promoting opportunities for residents to become certain about local SLR and its implications, and to develop informed opinions about the policies available to their communities.

Study limitations

The generalizability of our model of SLR beliefs and attitudes based on a sample of Maryland residents is difficult to surmise, though the survey responses generally appear similar to the other Mid-Atlantic surveys reviewed in Study 2. Regrettably, few of the measures across the five surveys are directly comparable. Differences in phrasing of the

policy questions make comparisons particularly tricky. This is especially true for measures of preferences for adaptation strategies.

Conclusion: Implications for research and implementation by coastal managers

The connection between public opinion and policy is not always clear, or direct, but researchers point to evidence that it is significant (Shapiro 2011). Public opinion can at times shift rapidly, while one survey provides just a snapshot at a given time. Longitudinal studies are necessary to estimate trajectories of public opinion, as well as to identify shifts in public opinion as a result of natural disasters or political events. Tracking surveys provide the opportunity to detect these changes quickly, and investigate causal mechanisms (Brulle, Carmichael, and Jenkins 2012).

In practice, surveys can be difficult to design and implement, and expensive to fund. The surveys reviewed were conducted in partnership with NOAA National Sea Grant College Program academic institutions, presenting a collaborative opportunity for local governments that may not have the expertise or funding to develop, implement, and evaluate public opinion surveys on their own. Communication programs and public consultation by governments can benefit from these types of collaborations and use of public opinion data on SLR for the purpose of evidence-based decision-making.

Public outreach and engagement are often prioritized as critical actions to address SLR (Yusuf et al. 2018) and yet poorly designed communications can do more harm than good (Covi and Kain 2016). Educators, and outreach and extension professionals need to understand their potential audiences to tailor their communications and provide relevant, salient information that will best prepare their coastal communities for the impacts of SLR. Surveys provide a scientific approach to understanding the spectrum of audience perceptions as well as information gaps or misunderstandings.

Managers can use these surveys to detect the degree to which public beliefs and attitudes remain unformed before committing substantial resources toward community engagement, to make decisions about the content to be conveyed to the public, and, over time, to monitor shifts in opinion. Notably, the Mid-Atlantic surveys did not filter respondents for only those with coastal residences. States and municipalities with significant shoreline exposure to SLR may be faced with large costs as flooding and inundation take their toll on public infrastructure and government services. The financial implications will likely be felt by these regions as a whole, not just those located on shorelines, requiring broad outreach—and corresponding understanding—of citizens.

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