

# Beyond the Blue Blob: Salience and Perceived Legitimacy of Alternative Sea Level Rise Visualizations

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**Abstract:** Experts in climate communication have long understood that depictions of potential extreme events may overwhelm audiences and be discounted in favour of more salient, near-term concerns. Despite this guidance, many coastal resilience processes rely on conventional visualizations of sea level rise that combine representations of worst-case storm events with high levels of sea level rise due to expert preferences or availability of modelling. To make projections salient and relatable to existing environmental signals, we advocate for separating depictions of the effects of sea level rise from depictions of storm surge and for depicting impacts of sea level rise that are relevant to near-term adaptation decisions such as roads obstructed by astronomical high tides. We test effects on perceptions of salience of sea level scenarios, storm surge risk, and legitimacy of visualizations as a first step toward testing the hypothesis that alternative sea level rise visualizations will be more effective tools for engaging the public in coastal resilience processes.

**Keywords:** Resilience, realism, visualization, sea level rise, storm surge

## 1 Introduction

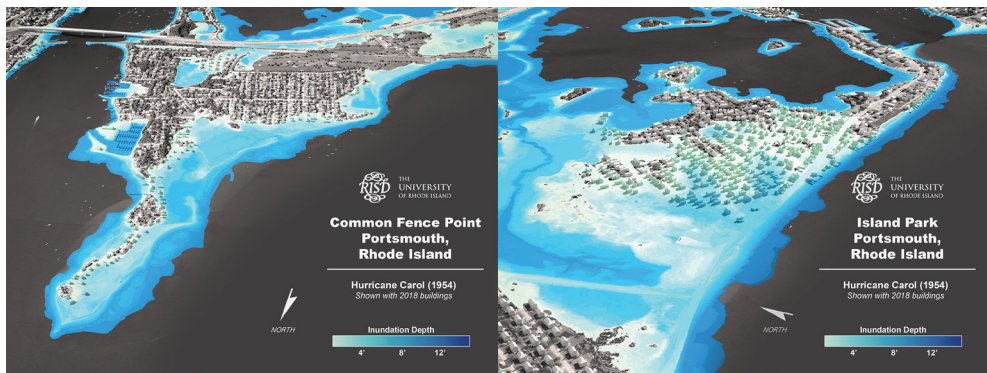
This work explores using semi-realistic 3D depictions of near-term impacts such as marsh migration and frequent road obstruction in lieu of inundation as tools to support resilience planning. We hypothesize that representing impacts related to observed experience such as septic failures and beach closures due to nutrient pollution occurring today or in the foreseeable future will be more salient to stakeholders and stimulate constructive engagement. This addresses an observed gap in the effectiveness of sea level visualizations used for engagement on coastal hazards. To develop a baseline understanding of viewer perceptions, we present a case study of visualizations of near-term sea level impacts used as part of a coastal resilience process in Portsmouth Rhode Island, USA (henceforth referred to as Portsmouth). We examine the use case for impact visualizations, explore factors affecting their utility such as the perceived salience of different scenario levels, and test the perceived legitimacy of these visualizations as a first step in addressing this hypothesis.

Sea level rise (SLR) poses an existential threat to many coastal communities. Intermittent flooding of roads due to astronomical high tides, septic system failures due to rising water tables, and marsh migration, among other impacts, create a nuisance to property owners and neighbourhoods and in some cases force abandonment long before residences are inundated. Municipalities must allocate limited adaptation resources and face the stark reality that providing services and access to all areas may not be feasible. Making policy, protocols, and incentives for retreat is politically difficult and requires earnest engagement by stakeholders. Decision makers turn to a variety of communication tools as part of the process. One such

tool, the conventional visualization of SLR, combines the effects of SLR and storm surge, displaying levels of inundation that completely submerge the neighbourhoods that face such adaptation decisions (e. g., SPAULDING et al. 2016). These visualizations depicting communities submerged beneath “blue blobs” of flood waters can overwhelm stakeholders, reduce feelings of self-efficacy, and lead stakeholders to discount risks (O’NEILL & NICHOLSON-COLE 2009). These feelings of helplessness were expressed by a local town councillor in the subject community who said simply: “you’re bumming us out”.



**Fig. 1:** Survey images from set 1. Depictions of Island Park (bottom) highlight Marsh migration (green), and obstructed roads (red) and mean high water (blue). Similar visualizations of Common Fence Point were also presented. (authors).



**Fig. 2:** Set 2 of survey images. Visualizations of Hurricane Carol’s storm surge at today’s sea level and buildout at Common Fence Point (left) and Island Park (right) (authors)

The localization of impacts, which has long been thought to be an effective means of increasing salience and risk perceptions of sea level impacts to inform resilience planning (RETCHESS 2014), has been called into question by recent research that suggests localization using inundation maps might not be effective at promoting adaptive behaviour (MILDENBERGER et al. 2019, SCHULDT et al. 2018). We argue that localization, in and of itself, is insufficient to overcome other heuristics of risk perception that cause stakeholders to discount

risk. The visualizations tested in this study separate depictions of storm surge from SLR so as not to conflate the inevitable effects of SLR with a low probability event (Figure 1, Figure 2). They emphasize impacts such as road obstruction and marsh migration that occur beyond mean high water and can be associated with observable environmental signals that increase the salience of projected outcomes (OLMAN and DEVASTO 2020, DEVASTO 2018) (Figure 3).



**Fig. 3:** An example of an environmental signal. Flooded athletic fields likely subject to marsh conversion in Common Fence Point Park, 2018 (Michael Asciola, via MyCoast)

## 2 Methods

An online survey was developed in collaboration with Portsmouth and the URI Coastal Resources Center (CRC). This work was incorporated into a coastal resilience initiative conducted by CRC, Portsmouth, and local organizations such as the Common Fence Point Improvement Association. Portsmouth also engaged in workshops conducted by The Nature Conservancy in collaboration with the Rhode Island State Infrastructure Bank, however the survey was not integrated into these processes.

The survey was approved by the Brown University Institutional Review Board (protocol 1908002510). It was promoted through a press release by the town leading to coverage by local newspapers and social media sites. Participation was voluntary, and all responses were anonymous. No personally identifying data was collected. The survey was administered between October 7 and October 30, 2019 and was open to Rhode Island Residents over the age of 18. There was a total of 115 respondents.

The survey included two sets of model-based visualizations of existing conditions, SLR scenarios for .30m (1') and .91m (3') SLR (Figure 1), and storm surge from Hurricane Carol

(Figure 2). Marsh migration projections (Figure 1) were based on the Sea Level Affecting Marsh Migration (SLAMM) Model (Boyd et al. 2015). Storm Surge projections (Figure 2) were based on the ADvanced CIRCulation (ADCIRC) model using a new Hurricane Boundary Layer Wind Model that more faithfully captures the asymmetrical nature of storms (ULLMAN et al. 2019).

## 2.1 Survey Instrument

Introductory text at the start of the survey defined terms and provided summary explanations of the models, procedures utilized, and criteria used to determine whether a road was obstructed. Two introductory questions addressed where respondents resided and their experience with past storms, as repeated experience with comparatively low impact events can reduce perceptions of risk (Weber 2010). The main body of questions was divided into three sections, SLR visualizations, storm surge visualizations, and summary questions. The order of SLR and storm surge sections were randomized.

### 2.1.1 Questions about Saliency and Concerns for SLR Visualizations Set

SLR visualizations were viewed in pairs representing the two depicted neighborhoods at .30m and .91m of SLR respectively. After viewing each pair of SLR visualizations respondents were asked the following two questions to determine how salient the stakeholder perceived the scenario to be, and what concerns the respondent had in the depicted area:

*“Given uncertainty about the rate of sea level change, what year do you expect this level of sea level rise to be reached?”*

*“What are your concerns about this level of sea level rise in these locations.”*

### 2.1.2 Questions about Perceived Risk from Storm Surge Visualizations Set

This set of questions was designed to better understand how respondents perceived the risk of an extreme storm surge. Questions were framed to separate the perceived likelihood and severity of consequences to better understand the relationship between perceptions of probability and impacts reflecting our concern that the probability of extreme events is discounted. The timeframe is based on the typical length of a residential mortgage in the USA. After viewing the visualizations (Figure 2), respondents were asked:

*“How likely do you think a storm of this magnitude is in the next 30 years?”*

*“How severe would the impact of an event like this to be if it occurred today?”*

### 2.1.3 Summary Questions around Legitimacy of both Sets of Visualizations

This set of questions was designed to assess the perceived legitimacy of the visualizations given their divergence from conventional SLR visualizations. They were asked after all visualizations were presented, as follows:

*“How trustworthy do you find the visualizations used in this survey to be?”*

*“What contributes to your perception of whether or not a visualization is trustworthy?”*

The survey concluded with five demographic questions addressing gender, age, race, income and political preferences, that were utilized to determine the representativeness of the sample.

## 2.2 Analysis

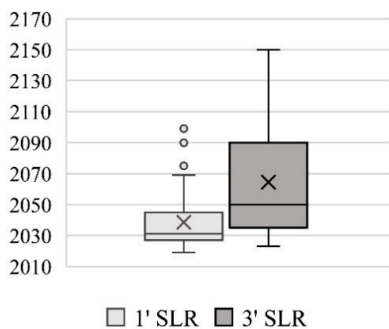
Evaluative questions used a five-point Likert scale. Open ended questions were analyzed by seven independent coders who reviewed all responses and identified themes using inductive coding (THOMAS 2006). A shared comprehensive set of themes was developed and then applied, then revised and reapplied by all coders. The application was validated by comparing agreement among coders applying the themes independently.

## 3 Results

Of the 115 respondents to the survey 48 lived in the depicted neighborhoods (21 in Island Park, 27 in Common Fence Point) and 47 respondents lived in other Portsmouth neighborhoods. The remaining 20 respondents reported being from Rhode Island or did not indicate residency. 93% of respondents recognized the places being depicted in the visualizations. Although the overall sample is generally reflective of the town demographics, sample size was too small to make definitive determinations.

### 3.1 Perceptions of Saliency and Concerns from the SLR Visualization Set

Responses to questions regarding the SLR visualizations suggest that respondents perceive lower levels of SLR to be more salient and are less likely to dismiss or disbelieve the projections. The median expected date for realizing .30m SLR was 2031; the average expected year for .30m SLR was 2039. The median expected year for reaching .91m SLR was 2050; the average expected year for .91m SLR was 2063 (Figure 4). The median of perceptions is slightly behind the National Oceanic and Atmospheric Administration “High Curve” SLR projection adopted by the State of Rhode Island (This lag is logical given that this curve overpredicts present sea level). There are higher levels of variation in the more distant projection. There were more uncategorizable responses with the distant projection (e. g., “never”). One stakeholder stated that the .30m scenario was “here already”.



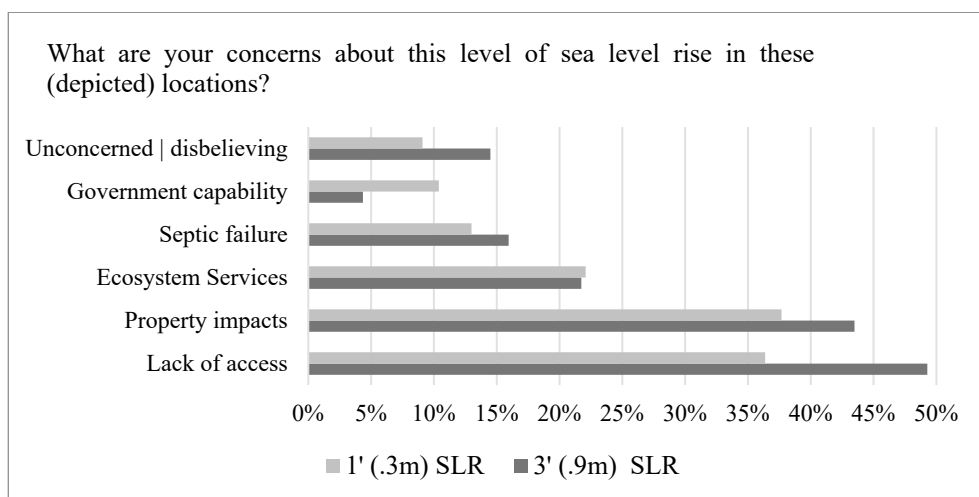
**Fig. 4:**

Respondent expectation as to when they expect to see the depicted level of SLR. “Given uncertainty about the rate of sea level change, what year do you expect this level of sea level rise to be reached?” “X” represents the mean, a horizontal line represents the median.

Responses to the question “What are your concerns about this level of sea level rise in these locations” were summarized into six thematic categories as described in Table 1. Responses to .30m SLR and .91m SLR were similar enough that responses were categorized together. In several cases, respondents referenced prior responses. The percentage of respondent answers falling in each category for .30m and .91m of SLR are summarized in Figure 5.

**Table 1:** Summary of major response themes

Theme	Description
Unconcerned or disbelieving	Unconcerned, flooding due to something other than sea level rise and/or climate change, disbelieving.
Government capabilities	Availability of resources such as current or future lack of municipal funds; the incapacity of government to respond.
Septic Failure	Issues stemming from failing septic systems.
Ecosystem Services	Impacts to salt marshes or beaches. Loss of ecosystem services (e. g., marsh is no longer a storm buffer, loss of recreation or fishing).
Property impacts	Physical damage, property devaluation or loss (e. g., abandonment) and expenses incurred (e. g., new septic systems and other expensive adaptations).



**Fig. 5:** Respondent answers falling into each thematic category for .30m and .91m of SLR

As with expected time horizon, the perceived saliency decreases with the higher scenario. For instance, and example of an unconcerned respondent:

*“I own property which you show as flooded. I am not concerned; it will be 100 years before this happens if it happens at all. I will be dead.”*

All categories include granular responses indicating a high degree of engagement with visualized outcomes. For instance, ‘government capability’ includes references to ongoing controversy over implementing sewers and the possibility they will spur gentrification. Respondents considered implications of visualized impacts beyond their own immediate risks:

*“Impassable roads, 1/2 my neighbors’ homes in the Hummocks next to the Sakonnet River bridge would be uninhabitable.”*

### 3.2 Respondents' Risk Perceptions from Storm Surge Set

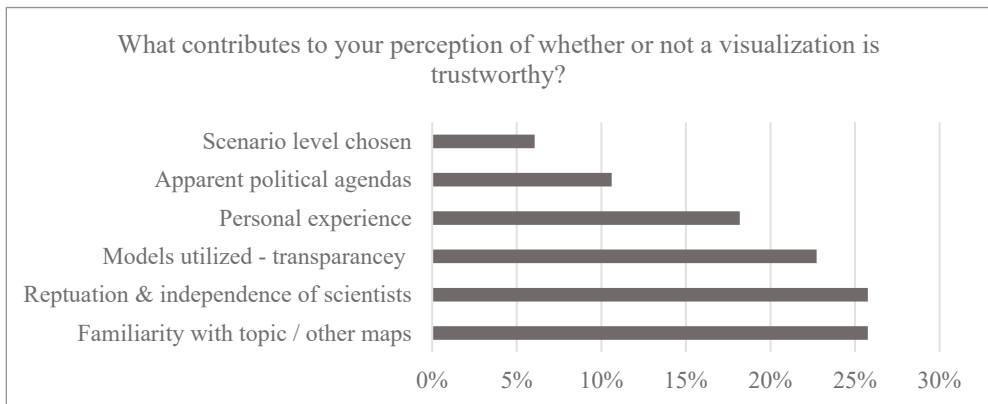
Participants were shown visualizations of Hurricane Carol (Figure 2) and asked, "How likely do you think a storm of this magnitude is in the next 30 years?" and "How severe would the impact of an event like this to be if it occurred today?" The likelihood of a storm of the magnitude of Hurricane Carol occurring today was regarded as being low (Mean 1.58 / 5). One respondent went so far as to say:

*"Hurricanes in New England are not like down south. We've had one hurricane that amounted to anything serious, a few days without power and trees down."*

The impacts of a storm like Carol, however, were regarded as being severe (Mean 4.58 / 5). Respondents saw few options for the town beyond ensuring adequate evacuation.

### 3.3 Respondents' Perceptions of Visualization Legitimacy for Both Sets

Participants were asked "How trustworthy do you find the visualizations used in this survey to be?" They regarded the visualizations as being trustworthy (3.9/5). Participants were also asked "What contributes to your perception of whether or not a visualization is trustworthy?" Factors contributing to their evaluation of the visualizations are summarized in Figure 6.



**Fig. 6:** Factors contributing to impressions that visualizations are trustworthy

Stakeholders view the impact visualizations presented as being like other more familiar sea level visualizations. They clearly rely upon reputation and other cues, such as transparency of methods and sources to judge the legitimacy of visualization. Moreover, they regard themselves as highly informed and familiar with SLR related visualizations and projections and are also familiar with the consequences of their vulnerability.



## 4 Discussion

### 4.1 Salience of SLR Concerns

Results suggest near term scenario levels were perceived as being more salient, and less likely to be dismissed or disbelieved. This is indicated by both the results regarding the expected time horizon, and in written answers that suggest increasing levels of being unconcerned or disbelieving of higher scenario levels. We observe that there is an inherent tension between expert-selected visualized scenarios that inform the public of worst-case inundation projections and the lesser-impact visualized scenarios that are likely to be more effective at engaging a cross section of participants and eliciting actionable concerns.

Stakeholders related projected areas of vulnerability to current issues such as failing storm drains and water table changes are already occurring in some locations. One respondent remarked that the .30m sea level scenario was “here now”. These responses suggest that lower scenario levels reflecting existing environmental signals are likely effective. A comparative study will be necessary to make a definitive assessment.



**Fig. 7:** This realistic 3' (.91m) SLR visualization illustrates the consequence of inaction (authors)

Despite the granularity of concerns, there is no evidence that the kinds of responses derived are any different from responses that would have been offered for a SLR only visualization showing inundation. Anecdotally, this became clear to the research team when a realistic “no action” visualization was utilized outside of the survey (Figure 7) and became an article of



shocked fascination as individual stakeholders came to grips with a landscape that was at once familiar and unfamiliar. A seasoned emergency manager became emotional as he looked for his own house and discovered it was not there. This visualization pointed to the capacity of still visualizations to transcend personal (effects on one's own house) and global (effects of climate change) scales, and to make future conditions tangible in a way that fostered deep reflection (OLMAN & DEVASTO 2020).

## 4.2 Discounting of Storm Surge Probability

Although direct observed experience enhanced perceptions of sea level risk, repeated experience with comparatively less powerful hurricanes appears to have caused some respondents to discount the likelihood of a major storm. 41% of respondents experienced a hurricane in Portsmouth. Despite these experiences, many answers minimize or dismiss the hazard (e. g., "Hurricanes in New England are not like down south. We've had one hurricane that amounted to anything serious, a few days without power and trees down."). This discounting conforms to heuristics of risk perception that suggest repeated experience with lesser storms may reduce risk perception (WEBER 2010). There is thus value in disentangling the effects of SLR and storm surge.

## 4.3 Perceived Legitimacy of Alternative Visualizations

As previously stated, respondents were remarkably frank about the extent to which they made judgements based upon experience with similar visualizations. Further, it does not appear that the choice to represent marsh migration and road obstruction caused stakeholders to distinguish these visualizations from others using more conventional coloration.

The high degree of trust placed in the visualizations based on reputation, emphasis on transparent peer reviewed practices, and personal heuristics comports with other research on the topic of perceived legitimacy of visualizations and computer models (FOGG and TSENG 1999, STEMPEL 2021). Although scenario level is the least frequently cited characteristic, answers elsewhere in the survey, such as the increase in disbelief of the higher level of SLR, suggest that scenario may influence the perceived legitimacy of projected outcomes, or may at least be used as a stated reason for discounting risk. Similarly, statements (e. g., "it does not seem that the visualization uses worst case scenario numbers") suggest that qualification is required to avoid undermining perceptions of legitimacy on the part of those who are concerned that the scenarios understate risk.

## 5 Conclusion and Next Steps

The evidence from the survey suggests that there is likely a benefit to separating storm surge and SLR visualizations because of the increase in perceived salience of SLR only visualizations and evidence of discounting of the probability of a significant event. There is, as of yet, no evidence that the semi-realistic impact visualizations that were tested offered any improvement over more conventional representational tactics. Like other innovations, more effectively depicting consequences does not in itself appear to be transformative. Based on this work, we identify the following clear needs for a comparative study. First, assessing impact depictions requires additional comparative sets such that the depiction of impacts can be disambiguated from depiction of scenario level. Moreover, in this study, different scenario lev-

els did not yield substantially different insights, thus understanding the tradeoffs between scenario level and perceived saliency will aid in optimizing scenario selection. Second, the anecdotally observed rhetorical power of the “no action” scenario suggests expanding the range of impact visualizations tested to include inundation, semi-realistic visualizations, and realistic visualizations.

In both cases, testing perceptions of legitimacy will be essential. In the first case, disbelief and lack of concern is closely related to scenario level. Establishing whether these factors alter the perceived legitimacy of the visualizations or the scientists and visualizers behind them is thus necessary. In the second, it is unclear how realism will affect the perceived legitimacy of the visualization. Although intuition might suggest increased realism will be perceived as less legitimate, the power of attribution and reputation are significant enough that these visualizations may nonetheless be perceived as products of science if they are attributed to experts, creating complex ethical situations if these visualizations are not used in appropriate engaged processes with qualification (STEMPEL 2021).

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