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The role of proximity to waterfront in residents' relocation decision-making post-Hurricane Sandy

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ABSTRACT

The experience with Superstorm Sandy advanced the dialogue on the long-term response options that would minimize risks and ensure livability in high-risk coastal environments. One strategy considered permanent relocation of homes from flood-prone areas. However, little is known about the factors that might influence a homeowner's decision to relocate, how their home's proximity to the shoreline may affect their risk perceptions and willingness to relocate. This paper explores the role that proximity to the oceanfront plays in relocation decision-making. It examines geospatial determinants collected as a part of a 2013 household survey conducted post Hurricane Sandy and their relationship with survey responses and socioeconomic predisposition. The analysis uses geospatial data to assess the proximity attributes of participating households. The proximity parameters were statistically compared to the socioeconomic profile and survey responses. The results demonstrate that the location of surveyed households, even though adequately dispersed to the oceanfront proximity, had only a minor effect on the willingness to relocate, suggesting that non-geophysical factors, such as household-level confidence in the ability to adapt and continue habitation in such locations, values, and other qualitative personal factors play a larger role. The findings also show that participants living closer to the bay are more likely to consider relocation if exposed to repetitive flooding and offered participation in buyout program.

1. Introduction

Coastal cities have been increasingly affected by coastal hazards. Scientists project that these events will occur with an increasing frequency and magnitude in some areas due to accelerated sea-level rise and larger populations living on the coast (Bender et al., 2010; Villarini and Vecchi, 2013; Kim et al., 2014). The sea level rise impacts will be more pressing on long-term horizons, while changes in storminess, wave activity, and resulting increase in episodic flooding (Knutson et al., 2010; Irish et al., 2014; Zanuttigh et al., 2015) and erosion will be more damaging to coastal built environments in the immediate future (McNamara et al., 2015). Future episodic and chronic flooding will exert a significant pressure on social, environmental, economic, and built systems (Alexander et al., 2012) and, as such, could compromise the livability of coastal urban centers (Frey et al., 2010; Nicholls and Cazenave, 2010; Sallenger et al., 2012). Geospatial proximity to hazards influences individual's perception of risk and risk-based decision making (Brody et al., 2004; Haynes et al., 2008; Maderthaner et al., 1978; Severtson and Burt, 2012). However, it is unclear how proximity to risk affects individual homeowner's willingness to consider relocation, especially after exposure to a major disaster. This paper analyzes resident's post-Sandy perceptions about relocation against distance measures from coastal hazards (oceanfront and bay side distance), as well as house elevation.

1.1. Hurricane sandy as a wakeup call

Hurricane Sandy hit the United States (U.S.) Eastern Shores in October 2012, and caused significant storm surge, storm tide, and damaging waves. It brought extensive flooding to New York, New Jersey, and Connecticut (Blake et al., 2013). It resulted in 147 fatalities in the U.S. with 72 direct deaths mostly due to storm surge and fallen trees, and 87 indirect deaths caused by power outages, making Sandy the deadliest U.S. tropical storm in Northern states since Hurricane Agnes (1972) (Blake et al., 2013). The damages to housing stock were also extensive. Five-million residences and 324,000 housing units were damaged or destroyed, and 22,000 fully uninhabitable in New Jersey and 305,000 in New York (Blake et al., 2013). The overall loss in the U.S.

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was estimated to be $65 billion (NOAA, 2013; Rosenzweig and Solecki, 2014). Some coastal jurisdictions such as Monmouth and Ocean County in New Jersey and Staten Island and Rockaway in New York, as well as the majority of barrier islands experienced disproportional damages due to extensive inundation with water, sand, debris, and change in sediment deposition and overall landform (Blake et al., 2013). The Hurricane Sandy disaster served as a wakeup call for many communities on the Eastern Seaboard, especially considering the low expectation that an event of such magnitude could occur in highly-urbanized metropolitan areas like NY City and New Jersey. It highlighted the risks of living along the coast, unique urban socioeconomic and physical vulnerabilities, as well as the long-term challenges associated with accelerated sea-level rise. The increased awareness about the vulnerabilities of infrastructure, transportation networks, residents, services, and critical facilities resulted in the proliferation of various initiatives and programs, some focused on adaptation and disaster risk reduction, some on integrated strategies, some on structural and soft measures, and some on relocation via buyout programs.

1.2. Response options

To reduce short-term and long-term risk of coastal hazards like Hurricane Sandy, coastal communities can take a variety of actions: a) protect their assets and population via structural or non-structural interventions; b) accommodate changing conditions by improving coping strategies, and c) retreat or relocate away from the shoreline through property acquisition, buyouts, or relocation programs (Nicholls and Tol, 2006; Klein et al., 2007; IPCC, 1996). The preferences for different strategies will depend on the local context such as political and public support, financial and technical resources, institutional capacities, affluence, and sociocultural determination to continue habitation in the increasingly challenging environment. It will be also influenced by the progression of impacts influenced by other local characteristics such as topography, hydrology, ecosystem, land use, built environment, natural resources, tourism, navigation, and presence of other hazards. Due to the complexity of hazard risks in some areas, such as barrier islands and those with complex networks of interconnected waterways, the available adaptation options may be limited either to the combination of strategies or relocation. Even though relocation may be the most appropriate option for low-lying coastal areas, like barrier islands, the implementation of this strategy may be only possible after coastal governance and institutional frameworks integrate it with other planning and development objectives (Abel et al., 2011).

Despite the challenges, relocation represents an effective coastal-flooding hazard mitigation (Drabek, 1986; Tobin and Peacock, 1982; Perry and Lindell, 1997; Williams, 2013) and climate change adaptation strategy (Adger et al., 2007; Warner, 2009; Tacoli, 2009; Gemenne, 2010; Barnett and Webber, 2010; McLeman and Smit, 2006; Leighton et al., 2011; Warnecke et al., 2010; King et al., 2014). Case studies describe the complexity of relocation process in numerous communities (Alaska Climate Change Sub-Cabinet, 2010; Cronin and Guthrie, 2011; Patel, 2006; Campbell et al., 2005; Maldonado et al., 2013). The 3rd National Climate Assessment report (USGCRP, 2014) urges additional consideration of relocation due to accelerating sea level rise, coastal storms, erosion, and inundation. Up to half of socially-vulnerable coastal areas may experience forced displacement resulting from insufficient resources for structural protection and lack of political support for proactive relocation (USGCRP, 2014). Much is known about disaster evacuations and displacement, especially from the riverine flood-prone areas, both in the U.S. (Davidson, 2005; Buss, 2005), and internationally (Nigg and Tierney, 1993). Hurricanes Andrew, Katrina and Sandy initiated a spur in research on displacement decision-making, acquisition and buyout programs, and population movement (Groen and Polivka, 2010; Landry et al., 2007; Elliott and Pais, 2006; Smith and McCarty, 1996). Also, more is known about the drivers of relocation and which factors seem to be important in disaster-related mobility decision-making, such as race/ethnicity, wealth, homeownership, education, age, gender, marital and homeownership status, and employment (Black et al., 2011; Landry et al., 2007). But there is still a need to advance dialogue on relocation as an adaptation strategy, optimal implementation strategies, mechanisms of public participation, and policy support (Blanco et al., 2009; Gromilova, 2014; Warner et al., 2013).

Relocation, also referred to as managed retreat (Alexander et al., 2012), has been received with mixed opinions in New York (Kaplan, 2013; Roy, 2013) and New Jersey (Attrino and Spoto, 2015) and has gained limited attention in coastal Alaska and Louisiana (Maldonado et al., 2013). Nevertheless, as the accelerated and more persistent coastal flooding is becoming a more pressing problem, it is prompting some communities such as Alaskan remote villages to consider relocation due to decreasing Arctic sea ice, thawing permafrost, repetitive flooding (Bronen, 2015; CAKE, 2011; GAO, 2003; ACCAP, 2009). Other examples include the frequently flooded Kamgar Putala slum in India which was relocated to a new housing community in Pune located outside the flood prone area (Cronin and Guthrie, 2011); a community in Grantham, Queensland (Australia) which was quickly relocated after the 2011 devastating flash flooding (Okada et al., 2014); and Isle de Jean Charles in Louisiana which was relocated due to land loss (Lowlander Center, 2015). However, research on anticipatory or preventive, as well as more extensive collective relocation is prevalently lacking.

The factors that influence a homeowner's decision to participate in such a program, however, are complex and not well understood (Bukvic et al., 2015). Managed retreat programs are considered drastic methods of decreasing risk by some (Greer and Binder, 2016), and can impose negative impacts on the residents through loss of sense of community, loss of culture, economic hardship, and psychological distress (Binder et al., 2015). However, some communities, most notably in rural Alaska and Louisiana, successfully overcame potentially negative impacts by active engagement in the planning and implementation process (Maldonado et al., 2013).

Buyouts have been proposed to effectively manage retreat (Kousky, 2014). The most notable home buyout program was established by the Governor Andrew Cuomo in New York State in 2013 and offered eligible homeowners the pre-storm value of their house pre-Sandy, plus other monetary incentives to increase the participation rates (Governor's Office of Storm Recovery, 2016). Homeowners were eligible for an additional ten-percent of their pre-storm home values if they jointly signed up to sell their property within the continuous neighborhood blocks, and for the five-percent increase if they relocated within the same jurisdiction, but outside of the high-risk zone (Governor's Office of Storm Recovery, 2016; Kaplan, 2013). The uptake of buyout programs varied across different communities. In Oakwood Beach on Staten Island, the program was highly successful with 180 homeowners participating (Fee, 2015), while in some other neighborhoods people were committed to staying in place (Kaplan, 2013). In Nassau County, officials opted out of the buyout program due to concerns with the loss of housing stock, loss of tax revenue, and perceived low levels of interest (Bonilla, 2016; McDermott and Ryan, 2013). The Blue Acres Buyout Program in New Jersey similarly offered homeowners options for relocation out of the disaster-prone areas. The program offered pre-storm market value to more than 500 homeowners affected by Hurricane Sandy and eventually achieved enrollment of 200 homeowners at a cost of $300 million to obtain their properties (Blue Acres Buyout Program, 2016).

1.3. Role of proximity

Proximity plays an important role in risk perceptions of various hazards (Lindell, 1994; Peacock et al., 2005) and related actions people are willing to take to mediate their hazard exposure (Lindell and Hwang, 2008). For example, in the case of proximity to a nuclear reactor, Maderthaner et al. (1978) found that individuals living closer to the hazard underestimated risk, suggesting that frequent contact with hazardous objects may reduce the perceived risk. Moreover, according to Few et al. (2006), visible post-disaster impacts are more likely to instigate public response and engagement in adaptation than the mere anticipation of future damages. Similarly, studies show that familiarity with a given hazard may not only affect an individual's perceptions of risk, it may also influence their behavior. A 2008 study evaluating perceptions of volcanic risk found that individuals living near a volcano interpreted their level of risk based on their personal past experiences and not on the scientific or official recommendations (Haynes et al., 2008). The results suggest that the proximity to, familiarity with, and the derived benefit from the hazard may influence the individual's behavior regarding risk reduction decisions such as relocation or evacuation (Haynes et al., 2008). Other studies determined that the close proximity to hazards is related to heightened risk perceptions (Brody et al., 2004; Lindell and Hwang, 2008; Severtson and Burt, 2012). In the context of contemporary coastal hazards, Brody et al. (2004) attested that proximity-based physical vulnerability factors are correlated with risk perceptions of climate change with residents living further away and on higher elevations being significantly less concerned and those living closer to sea-level rise inundation zone being more concerned. On the sample of 5815 New Zealanders, Milfont et al. (2014) found that respondents residing in closer proximity to the shoreline were more convinced in climate change, even when adjusting for the elevation factor.

This paper provides insight into the role proximity plays in cognitive decision-making and how location influences risk perceptions, concerns with repetitive impacts and future damages, and consideration of relocation as a possible response strategy. Factors explored in this assessment include Light Detection and Ranging (LiDAR) derived ground elevation, distance from the Atlantic shore, and distance from any waterbody, using near analysis, coastline delineation, and Digital Elevation Modeling (DEM). Most acquisition, buyout, and relocation programs are voluntary in nature, and most effective when implemented before a storm event. This study provides new information about which factors drive this decision-making process, which ones are more impactful and which ones are irrelevant based on context specific circumstances. Further, this information can help guide new research inquiries into self-perceived household capacity to cope with repetitive exposures and withstand multiple shocks.

2. Methodology

This research project explores the role of geospatial factors in relocation decision-making, building upon the Bukvic et al. (2015) household survey that measured factors that drive the willingness to consider relocation after the exposure to the Hurricane Sandy disaster. A door-to-door survey (n = 125, IRB#11-725) was conducted seven months after Sandy among the residents in highly-affected Nassau County, New York and Atlantic, Monmouth, and Ocean Counties in New Jersey. The survey collected information on the socioeconomic profile, levels of preparedness, community embeddedness, and attitudes towards relocation to evaluate the concerns that would prompt homeowners to participate in the relocation programs (Bukvic et al., 2015). Fig. 1 shows the socioeconomic profile of surveyed participants who are all white, 50% female and 50% male, 90% age 45 and older, and mostly longer-term residents in surveyed households (26% living in the same house for more than 30 years, 18% 20–30 years, 29%10–20 years, 14% 5–10 years, 6% 3–5 years, 6% 1–3 year, and 1% less than a year).

The survey locations were identified using FEMA's Remotely-Sensed Damage Assessment data to generate the map of Hurricane Sandy high-impact areas based on the levels of structural damage and included Ventnor City, Longport, Margate City, Lavallette, Pine Beach, Manasquan, Belmar, and Long Beach. The final analysis included 118 responses with 5.6% missing variables. The research described in this paper queried the impact of geospatial factors on residents' consideration of relocation post-disaster. The survey responses were geospatially and statistically analyzed against the household unit's: 1) distance to the coastline; 2) distance to the bay; and 3) elevation.

2.1. Geospatial analysis

To support high resolution geoprocessing, we divided the study locations into four distinct study areas: Long Beach, New York; and in New Jersey Monmouth County, Ocean County, and Atlantic County (Fig. 2). We obtained the ground elevations in the North American Vertical Datum of 1988 (NAVD88) for the study area from LiDAR data collected one month prior to Sandy (USGS, 2012a). Household survey locations were georeferenced with address data sourced from New York Office of GEOCODE server (2016) and from the New Jersey Bureau of GIS REST directory (2016). We obtained the boundary data including road networks, city, town, county, and state boundaries, from the New Jersey Bureau of GIS and the New York State GIS Program Office's websites.

The desired level of spatial resolution for selected boundary files was manually developed for this research project. We created new GIS Shapefiles, which include:

1) Delineation of the Atlantic Ocean coast for each study location;
2) Delineation of the landward bay coastline for each study location;
3) Driveways connecting the survey households point to the roads shapefiles;
4) Area of interest extent boxes to define the processing extent for each study area.

We used high-resolution orthophotography as a visual reference to accurately delineate coastlines based on the wet/dry interface of the water and the land to represent the visible "edge" of the water, as described in Hoeke et al. (2001). Pre-Hurricane Sandy imagery photographed on multiple flight dates in the spring of 2012 was obtained from the U.S. Geological Survey's Earth Explorer website (USGS, 2012b). All geoprocessing was executed using ESRI ArcMap 10.3 (Redlands CA). The rasters and shapefiles were clipped to the areas of interest and geoprocessing was performed separately for each study area, which included all survey households within the given county, the Atlantic Ocean shoreline, the adjacent landward-bay shoreline, and significant road interchanges around the survey cluster.

Geocoding required residential addresses, a valid street number, street name, and zip codes. Due to the extensive damage caused by Hurricane Sandy in the survey neighborhoods, and the lapse of time between geocoding and the initial survey, 107 households (86%) were able to be confirmed in 2016 of the 125 originally surveyed in 2013 (Table 1). The remaining unconfirmed 18 households were not analyzed in this study. To achieve the desired resolution of oceanfront and bay coasts of the barrier islands, high resolution (0.3 m) aerial imagery was used to manually delineate the boundary between the landmass and water bodies. Out of 107 surveys analyzed, 44 were conducted in Atlantic County, 20 in Monmouth County, 39 in Nassau County, and 4 in Ocean County (Table 1). The low response rate in Area 4 resulted from the data collection logistical issues in 2013 related to the weather conditions, the time of the week with fewer responders available to take the survey, inaccessibility to residences due to post-disaster conditions, and the overall residential density.

This study evaluates the distance from the survey locations to the areas of hazard, which is, in this case, represented by the presence of water as a potential hazard that can lead to extensive flooding and damages. As such, we define the hazard as the point at which the land and water converged, either on the Atlantic Ocean side (i.e., oceanfront coastline) or landward bay's side (i.e., bayline). To determine the distance to hazards, we ran a Near Analysis in ArcGIS for each the four areas of interest based on the survey household's distance to the

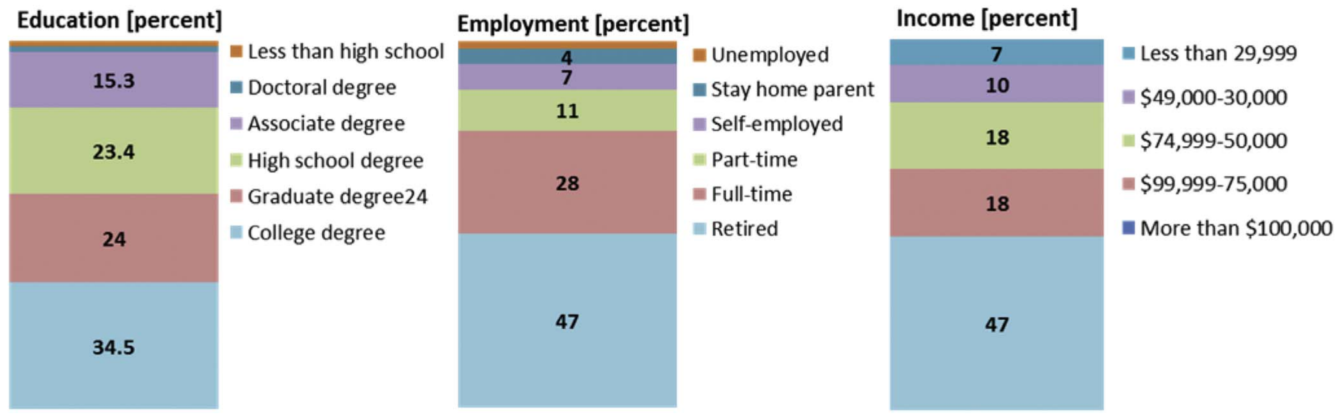

Fig. 1. Socioeconomic characteristics of survey participants.

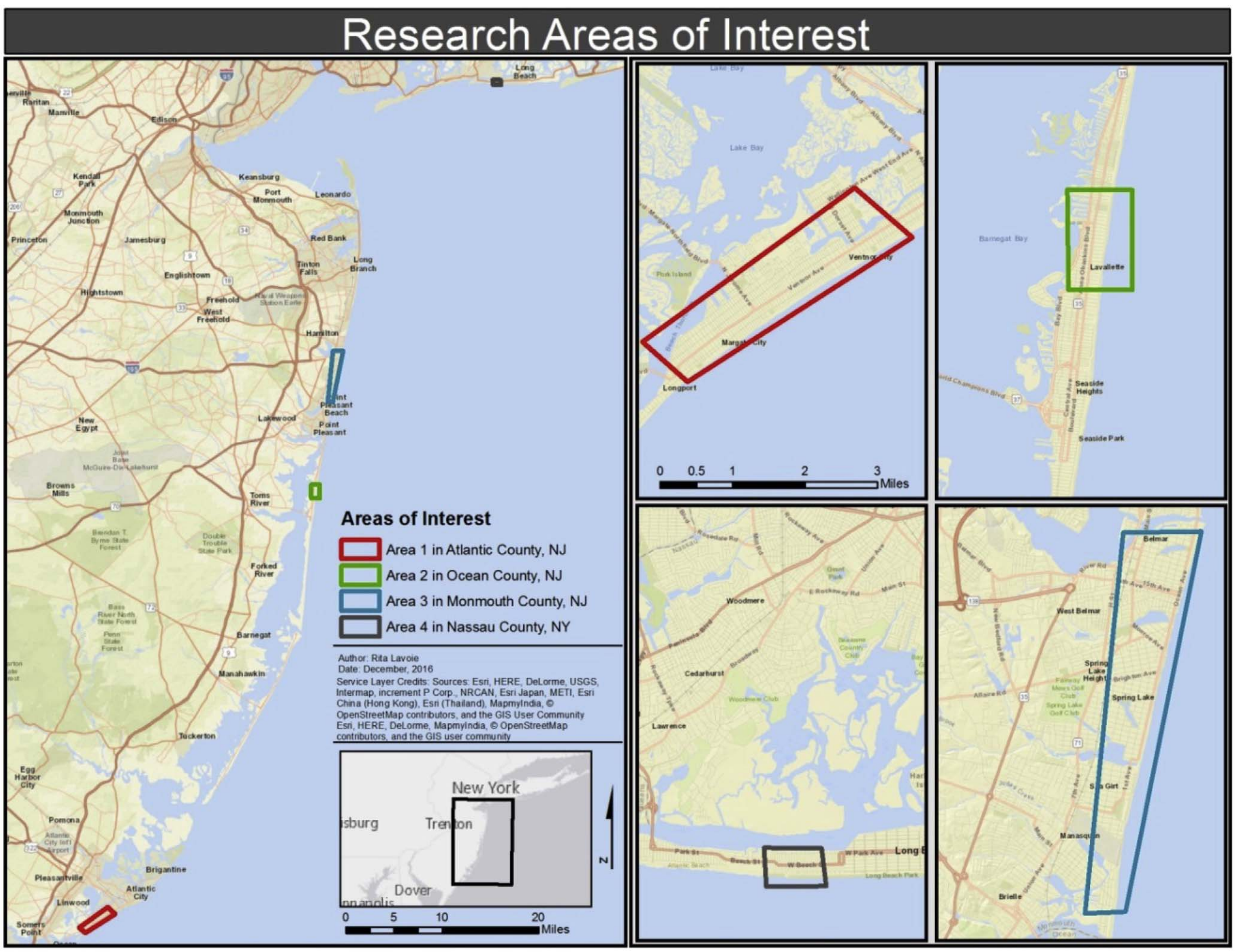

Fig. 2. The study locations in New York and New Jersey States.

Table 1
Profile of survey locations.

Study Area	County	State	# of surveyed households	Average elevation (m)	Population	# of households in the study area
Area 1	Atlantic	NJ	44	1.89	15,196	7034
Area 2	Monmouth	NJ	20	3.13	12, 332	5599
Area 3	Nassau	NJ	39	2.29	5207	2732
Area 4	Ocean	NY	4	1.60	1559	814

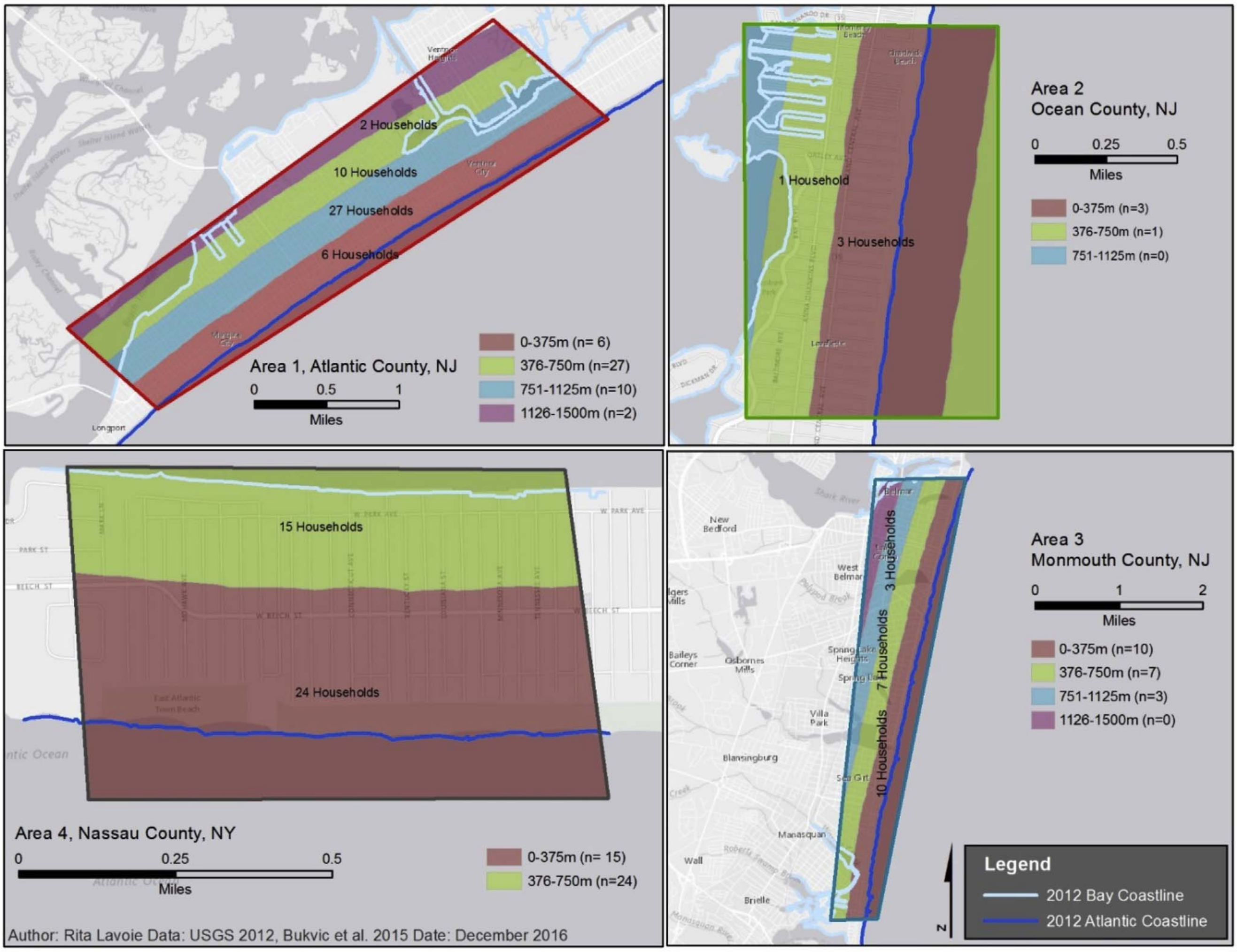

Fig. 3. Average elevation of survey households by county recorded as meters above NAVD88 base elevation are shown compared to the recorded storm tide heights collected by Department of the Interior monitoring sites during Superstorm Sandy (Schubert et al., 2015).

coastline and repeated the analysis for the distance to the bayline. The planar distance between each household and its nearest hazard was calculated and added to the attribute table. As the aerial imagery was captured at different times, there may be a range of tidal heights represented in the imagery and thereby in the coastline analysis. At high tide, the coastal hazard may appear closer to the households than at low tide. This impact was minimized by utilizing the wet/dry interface as the coastal delineation, but the potential source of error, although minimal, is not fully extinguished. Tidal range on the ocean side is generally less than 0.25 m and on the bay side can be 1.5 m for some locations.

2.2. Statistical analysis

The correlation between three geospatial proximity variables and the 2013 survey responses was calculated using statistical tests. The three additional geospatial variables are:

(1) Elevation (meters);
(2) Distance-to-ocean (meters);
(3) Distance-to-bay (meters).

The survey responses refer to items that were identified as relevant to the relocation decision-making by Bukvic et al. (2015). They include three sets of measures: stress measures (8 items), recovery concerns (10 items), and relocation drivers (13 items) (discussed in detail in Bukvic et al., 2015). Analysis included the correlation calculation between the level of damage/loss (extent of property damage, resource loss, and how soon they returned after Sandy) and the proximity variables, as well as the correlation between the socioeconomic status and the proximity variables. These statistics measure whether the level of damage or any socioeconomic variable are significantly correlated with the proximity measures. In addition to the correlation measures, assessment also explored whether having flood and personal insurance is significantly associated with the proximity variables though performing logistic regressions.

When calculating the correlation between the survey measures and distance-to-ocean and distance-to-bay, our approach only considered the distance to the nearest hazard as relevant. For example, when calculating correlations with the distance-to-ocean variable, the estimates only included the samples with a household location closer to the ocean; and when calculating correlations with the distance-to-bay variable, they included only the samples with household location closer to the bay. For this purpose, the total sample was further split to two categories based on the households' proximity designations: closer to the Ocean (32 households) and closer to the Bay (75 households). Considering that the survey was conducted soon after Hurricane Sandy, the housing blocks that had intermediate proximity to the ocean side were either severely damaged or inaccessible for safety reasons. Therefore, many houses closer to the ocean at the time of the survey collection became the new ocean housing forefront. Out of 44 houses in the Atlantic County (NJ), 5 were closer to the ocean and 39 were closer to the bay. In Monmouth County (NJ), there were 14 houses closer to the ocean and 6 were closer to the bay, while in Nassau County (NY) there were 10 closer to the ocean and 29 closer to the bay. Ocean County (NJ) had 4 houses surveyed (3 closer to the ocean and 1 closer to the bay).

3. Results and discussion

The geospatial analysis provides the base elevation and distance to coastal hazards for the subsequent statistical analysis. Elevation for the four study areas ranges from 1.0 below the North American Vertical Datum of 1988 (NAVD88) to 10.8 m above. All study area sites have the highest elevations along the Atlantic facing beaches. Satellite imagery and Google Street View confirmed that these highest elevations are sand dunes, which are non-permanent land features susceptible to change through wind and wave action. Highest recorded elevation (10.8 m above NAVD88) was in Monmouth County, where the study location was the largest of the four areas and protruded the furthest inland. The lowest elevation (0.8 m above NAVD88) was in Ocean County. In Fig. 3, we demonstrate the average elevations in the four study areas. The highest average elevation (3.1 m above NAVD88) was recorded in Monmouth County and the lowest average elevation (1.6 m above NAVD88) was in Ocean County. Fig. 3 also shows the recorded average magnitude of storm tides during Hurricane Sandy (recorded by a USGS monitoring site of peak storm tide elevations on the New York coast), which was 2.4 m. The maximum recorded peak storm tide elevation is 3.9 m, which was recorded in Nassau County, NY (Schubert et al., 2015).

Average distances from the surveyed households to the Atlantic Ocean were closest in Ocean County (274.2 m) and furthest in Monmouth County (1075.4 m). While average distances from survey locations to the corresponding inland bay were closest in Nassau County (245.4 m) and furthest in Monmouth County (858.85 m). The survey location furthest from any water body was 4432.2 m or about 2.75 miles, while the closest location to a waterbody was only 120.6 m away.

Fig. 4 shows the proximity of households to Atlantic Ocean, visualized as proximity corridors to protect the privacy of research participants (VT IRB 11-725). The proximity corridors within the surveyed area represent quantiles of the largest width of surveyed area and consist of four 375 m bands measured from the Atlantic coastline. According to the geospatial data analysis, the survey locations have low elevations, in some places just barely above the base NAVD88 elevation (0.8 m) and frequently below the average observed storm tide water height. Furthermore, they are located on the narrow coastal barrier islands surrounded by water on both sides with prevalently flat topography that places all structures in close proximity to the “water hazard”.

Table 2
Spearman correlations between stress measures and proximity variables, as well as the p-values (in parentheses). P-value < .05 indicates the correlation is significantly nonzero.

What is causing you to feel more stressed in the aftermath of Hurricane Sandy?	Elevation (meters)	Distance-to-ocean (meters)	Distance-to-bay (meters)
Thinking about recurring hazards in coastal areas	−0.1286 (0.1931)	−0.0817 (0.6622)	0.1817 (0.1239)
Thinking about rebuilding and recovery	−0.0182 (0.8541)	0.1755 (0.3451)	0.1543 (0.1923)
Thinking about filing insurance/ assistance claims	−0.0818 (0.4113)	0.1979 (0.2946)	0.1524 (0.1980)
Thinking about future in this community	−0.1084 (0.2735)	0.1351 (0.4688)	0.0878 (0.4602)
Thinking about moving somewhere else	−0.0131 (0.8959)	−0.0042 (0.9823)	0.0031 0.9796
Thinking about mold and corrosion	−0.0273 (0.7836)	−0.0713 (0.7033)	0.0871 (0.4637)
Thinking about lost personal belongings	−0.1127 (0.2546)	0.0151 (0.9359)	−0.0116 (0.9223)
Thinking about looting and crime	−0.1727 (0.0825)	−0.2147 (0.2545)	−0.0696 (0.5611)

The geospatial analysis provided the measurements for the subsequent correlation analysis between the survey responses and the three new geospatial proximity variables: elevation, distance-to-ocean, and distance-to-bay. The Spearman correlation was calculated between each of the survey response measures and the three proximity variables, and tested for the significance (i.e., whether the correlation is significantly different from zero) using the asymptotic *t*-test provided by the cor.test() function in the R software (R Core Team, 2016). Results are demonstrated in Tables 2–4. Table 2 shows the Spearman correlation (denoted by ρ in later text) between the eight items looking at the causes of stress in the aftermath of Hurricane Sandy and two proximity variables, together with the corresponding p-values for testing. Results show that stress measures are not significantly correlated with the elevations of the households and with the proximity variables, suggesting that distance to the water did not play an important role on the levels of experienced stress post Sandy.

Table 3 shows the Spearman correlation between the ten items of recovery concerns as drivers of relocation and the two proximity variables, as well as the corresponding p-values. Here, no recovery concerns were significantly correlated with the elevation, distance-to-ocean and the distance-to-bay in meter. The concern with the city rebuilding rules was found to be negatively correlated with the elevation measure, with

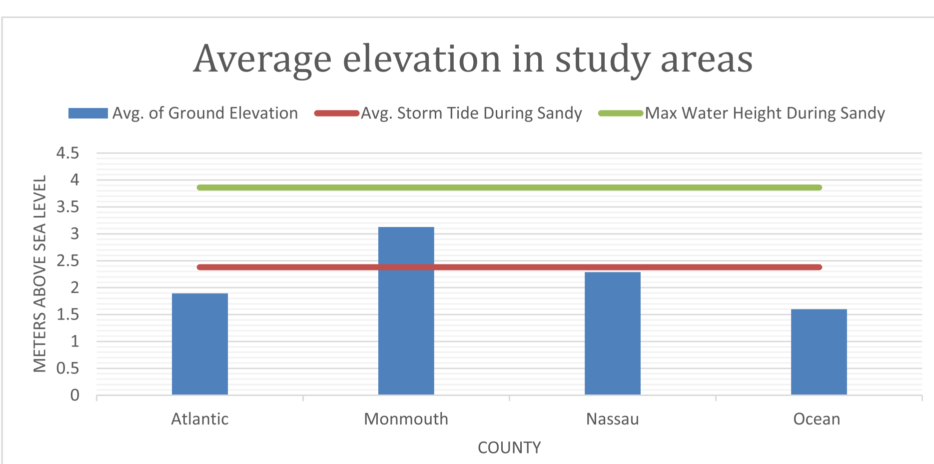

Fig. 4. Distances (meters) from Atlantic Ocean to households.

Table 3
Spearman correlations between recovery concerns and proximity variables, and the p-values (in parentheses). P-value < .05 (in bold) indicates that the correlation is significantly nonzero.

You decided to return. Which of these concerns may prompt you to consider relocation in the future?	Elevation (meters)	Distance-to-ocean (meters)	Distance-to-bay (meters)
Tax increase	−0.1888	−0.0111	0.1730
	(0.0587)	(0.9518)	(0.1551)
Insurance rates increase	0.0288	0.0964	0.0955
	(0.7724)	(0.6061)	(0.4248)
New FEMA advisory maps	0.0762	0.0006	0.0511
	(0.4467)	(0.9973)	(0.6721)
City rebuilding rules	**−0.2048**	−0.1801	0.0169
	(0.0390)	(0.3324)	(0.8885)
Neighbors, friends, and/or family moving out	−0.1521	−0.0196	−0.0949
	(0.1307)	(0.9180)	(0.4346)
Strangers in the neighborhood	0.0271	−0.1059	0.0643
	(0.7886)	(0.5774)	(0.5967)
Crime increase	−0.1360	−0.0738	−0.0678
	(0.1708)	(0.6933)	(0.5716)
Construction crews and activities	0.0405	0.0998	0.1175
	(0.6906)	(0.6065)	(0.3327)
Uncertainty when next flooding will occur	−0.0763	−0.0214	0.1586
	(0.4437)	(0.9091)	(0.1834)
Tidal inundation and frequent flooding	0.0423	−0.2650	0.0917
	(0.6747)	(0.1497)	(0.4502)

Table 4
Spearman correlations between relocation drivers and proximity variables and the p-values. P-value < .05 (in bold) indicates that the correlation is significantly nonzero.

I would consider relocation if:	Elevation (meters)	Distance-to-ocean (meters)	Distance-to-bay (meters)
We have one more flood in the next few years	−0.0809	−0.3093	**0.3151**
	(0.4145)	(0.0850)	**(0.0070)**
We have two or more floods in next few years	−0.0006	−0.2576	**0.2501**
	(0.9951)	(0.1618)	**(0.0354)**
Neighbors, friends, and family move out	−0.0739	0.0914	−0.0964
	(0.4626)	(0.6249)	(0.4274)
Businesses do not reopen	−0.0961	−0.1633	−0.0361
	(0.3340)	(0.3801)	(0.7633)
Crime becomes worse	−0.0705	−0.0156	0.0633
	(0.4792)	(0.9335)	(0.5974)
School system deteriorates	−0.0884	0.0086	0.0300
	(0.3772)	(0.9634)	(0.8040)
Services and amenities do not restore their full function	−0.0441	−0.0492	0.0506
	(0.6600)	(0.7927)	(0.6751)
Insurance cannot cover full reconstruction	−0.0288	−0.1065	−0.1459
	(0.7752)	(0.5687)	(0.2281)
I am offered financial compensation (buy out)	0.0415	−0.3283	**0.2402**
	(0.6817)	(0.0714)	**(0.0468)**
I can move together with my neighbors	−0.0901	**−0.3810**	−0.1686
	(0.3754)	**(0.0345)**`	(0.1694)
I receive assistance with finding a new job elsewhere	−0.0207	−0.2942	0.0915
	(0.8431)	(0.1363)	(0.4615)
I am provided with free legal advice on my options	0.0520	−0.2084	0.0651
	(0.6093)	(0.2692)	(0.5953)
I am offered comparable housing in similar community elsewhere	−0.0499	**−0.5067**	0.1989
	(0.6201)	**(0.0036)**	(0.0987)

households at the lower elevation being more concerned with this aspect that may prompt them to consider relocation in the future.

Table 4 shows the Spearman correlation between the 13 items that could instigate relocation, elevation, and the two proximity variables, as well as the corresponding p-values. In this analysis, five out of 13 relocation driver variables were found to be significantly correlated with the two proximity measures. Distance-to-ocean is significantly correlated with the driver "I can move together with my neighbors" and "I am offered comparable housing in a similar community elsewhere". The participants who live closer to the ocean are less likely to consider relocation if offered to move collectively "together with their neighbors" and if presented with the "comparable housing in similar communities".

These results suggest that homeowners living closer to the ocean purchased homes primarily for the personal gratification of having the ocean views or beach access and not because of the community. The premiums for waterfront properties significantly vary, but their value is generally more than double that of homes located further from the shoreline (Krause, 2014). Thus, suggesting that households located closer to the ocean are financially more stable and may have alternative housing options. Even with heightened awareness of erosion and coastal flooding due to increasing media coverage of these issues, many homeowners still choose to live along the waterline in ecologically-sensitive and hazard prone areas. Even though such homes located on the beach-water interface (or even past the sand dune barrier on the beach side) are at risk of repetitive damages; can inhibit public access to beach; disturb dune-beach system; accelerate erosion; and reduce protection for the inner structures they are still a frequent sight on many shorelines (Abbott, 2013). These higher-value homes place their occupants at greater risk of floods. Further, the residents cannot retreat landward with the progressing erosion, due to the presence of back bays and waterways (Titus, 1990).

Distance-to-bay is positively correlated to the items "we have one more flood in the next few years", "we have two more floods in the next few years", and "I am offered financial compensation (buy out)". This finding suggests that survey participants living closer to the bay are more likely to consider relocation if exposed to repetitive flooding and offered participation in buyout program. Thus, these homeowners may either have less attachment to the place, due to inferior location in respect to the ocean front, or their houses have less value than the prime oceanfront properties. For them, perhaps there is less to lose.

A further analysis examined the correlation between the levels of damage and exposure (extent of property damage, resource loss, and how soon residents returned to their homes after Sandy) and the proximity variables, as well as the correlation between several socio-economic determinants (age, education, income, and how longed they lived in the home) and the proximity variables. This analysis determined whether Hurricane Sandy's impacts and exposure, as well as pre-disaster household profile are significantly correlated to the waterfront proximity. Table 5 shows results from the Spearman rank-order correlations between seven additional variables and the three proximity variables. An exception was the correlation with the age variable, which was calculated using Pearson calculation that measures a linear

Table 5
Correlations between levels of damage-exposure or social economic status and proximity variables. The p-values were reported in parentheses. P-value < .05 indicates the correlation is significantly nonzero.

		Elevation (meters)	Distance-to-ocean (meters)	Distance-to-bay (meters)
Damage and Exposure	Property damage	0.0374	−0.0327	−0.0960
		(0.7063)	(0.8591)	(0.4226)
	Resource loss	0.0572	−0.1232	−0.1285
		(0.5644)	(0.5018)	(0.2822)
	How soon return	−0.0704	−0.2378	0.0590
		(0.4910)	(0.2230)	(0.6276)
Socioeconomic profile	Age[a]	−0.0292	−0.0044	0.1059
		(0.7672)	(0.9816)	(0.3659)
	Education	−0.0277	−0.0055	−0.0130
		(0.7766)	(0.9762)	(0.9119)
	Income	0.2061	−0.1675	0.0763
		(0.0741)	(0.4448)	(0.5871)
	How long live in home	0.1557	−0.0591	0.1110
		(0.1109)	(0.7480)	(0.3462)

[a] Age: the correlations between age and proximity variables were calculated using Pearson correlation.

relationship between continuous variables. Results suggest that none of the seven variables are significantly correlated with the elevation, the distance-to-ocean, or the distance-to-bay.

All other correlations were calculated using Spearman correlation.

In addition to correlation analysis, we also explored whether having flood and personal insurance is significantly associated with the proximity variables. This was done through logistic regressions that treat the insurance status (having or not having insurance) as the responses and two proximity variables (the elevation and the distance-to-ocean/bay) as the predictors. Similar as in the correlation analysis, when regressing the insurance status on the proximity variables, samples were split into two categories: those closer to the ocean and those closer to the bay. Only samples closer to the ocean were used to calculate the association between the insurance status and the distance to the ocean. This analysis helps answer the question of whether living closer to waterfront is significantly associated with the ownership of flood or property insurance. For both flood insurance and property insurance, we found that all proximity variables result in p-values greater than 0.05, which implies that elevation and the distance-to-ocean/bay are not significantly associated with flood/property insurance ownership.

Reinforcing the findings in Table 5, that show no significant association between the income level and distance to the bay, the supporting plotted spatial distribution of the sampled locations in four different survey locations shows random distribution of the household income level in comparison to the positioning closer to the bay or the ocean (Fig. 5).

Fig. 6 shows the spatial distribution of 107 sampled locations in the four study areas including their designation for the variable "for how long they lived in the household" and whether the household is closer to the bay or ocean. The distribution of the surveyed households, coupled with the results from the statistical analysis in Table 5, does not verify that surveyed participants living closer to the ocean/bay tend to live longer/shorter in the same household.

One explanation for the aforementioned results is that the homes closer to the bay were located in the interior zone before Sandy and not directly positioned on the oceanfront. Considering the survey was conducted soon after the disasters, the strip of oceanfront homes that used to be there prior Sandy was either destroyed or inaccessible. Survey participants living in homes designated as closer-to-ocean may still have had the perception that they were located in the safer interior area further away from the water and that when oceanfront homes are rebuild they will regain a perceived structural barrier serving as a front line protection.

Additional reasons for the observed results may be grounded in the survey strategy itself and the relationship between the questions and listed concerns to the physical positioning of participants' homes. For example, from the physical location standpoint, the affected households on the barrier island may feel equally exposed and vulnerable to flooding regardless of their exact location and actual proximity to the water. Rather, their risk perceptions may be driven by the sense of vulnerability in respect to accessibility to mainland, number of evacuation routes, and previous encounters with hazard events. Further, it may be possible that some household-level factors and considerations that were not addresses in this study have a higher importance in the decision-making process than the proximity of the home to the hazard. For example, perceptions of aging residents on risk and responses may be more influenced by their personal plans to, for example, eventually move closer to their family or into the retirement community than the other considerations such as taxes and flood insurance. For others, it may not be the proximity, but rather some other community changes related to disasters' direct or indirect impacts that may serve as catalyst for families to pursue different course of action. For instance, some have been thinking about moving for a while and, after the major disaster, this option is more appealing.

Even though the flood and property insurance ownership was not significantly associated with the proximity measures in this study, they were found to play an important role in the relocation decision-making (Bukvic et al., 2015). The survey participants with flood insurance were the least stressed when thinking about rebuilding and recovery, more concerned with the new FEMA advisory maps and crime increase post Hurricane Sandy, and more likely to consider relocation should they experience two or more floods. Participants with personal property insurance were the least stressed when thinking about recurrent flooding and damages, lost personal belongings, and the overall future in the surveyed community (Bukvic et al., 2015). The insurance uptake in hazard and disaster prone communities often depends on risk perceptions and if residents view the risk of adverse event happening as low, they will be less likely to purchase it (Kunreuther et al., 1978). Similarly, Browne & Hoyt (2000) found that the risk perceptions of flood loss represent an important determinant of insurance ownership, with higher income individuals being more likely to purchase the flood insurance.

Another factor that may be influential in relocation decision-making that was not captured in our analysis is whether surveyed houses had any structural retrofits and/or flood-proof features that would influence homeowners' confidence in their ability to stay and cope with coastal hazards. It is not well understood how other features such as positioning of primary and secondary roads, landmarks, and critical facilities may influence people's risk perceptions. This research did not consider the perceived feeling of safety among homeowners located in the second and subsequent rows of residential properties. These residents may feel that storm impacts will only affect those homes directly adjacent to the open water. If not in regard to risk, people frequently consider the proximity in their decision-making when purchasing a home, for example in relation to distance to schools, shopping areas, work location, as well as other landmarks and features that would affect their estate value. In the case of this study, it is likely that prospective buyers would assume that proximity to water represents a more desirable location, one that would ensure one's investment appreciates in value and maintains its resale potential. Even though this is likely changing with the heightened awareness of increased costs of living along the shoreline, still in many communities, the oceanfront properties and those with a direct connection to navigable waters are still more attractive properties that generate higher tax revenues for local governments than in other locations.

Our results stress the importance of understanding the hazards and risk perceptions of those living on the bay side or along coastal waterways, where some may feel safer and detached from the issue of proactive hazard planning. The oceanfront corridor often receives more policy and research attention, even though the bay side may also experience significant flooding. Most policy institutional mechanisms still revolve around planning for major disasters and episodic sudden hazard events rather than the chronic gradual impacts that often afflict bay-facing neighborhoods. In many of the tidally-influenced inner waterways and bays, coastal storms can generate wind waves and surge that can push the water up the tidal inlets and significantly increase the flooding (Irish and Cañizares (2009). For example, even though 1933 Chesapeake Bay-Potomac Hurricane was only a category 2 hurricane, it still produced extensive flooding due to storm-surge in the inner bay area with a storm tide of 2.4 m above the mean low water in many estuaries and up to 3.7 m in the narrow ones in the Norfolk Bay area (Kleinosky et al., 2007). Inundation via tidal inlets provides entry points between the ocean, bays, lagoons, and creeks that allows saltwater to penetrate further inland, while at the same time there is little research on how sea level rise will change hydrology and sedimentation process and exacerbate this type of flooding, which will not spare the houses located further away from the shoreline (FitzGerald et al., 2008). Picou (2009) notes that modern disasters are more complex and cause chronic community stress and social and psychological impacts that hinder the recovery process while the "programs for mitigating chronic impacts are non-existent." Estuaries and back bays may also get

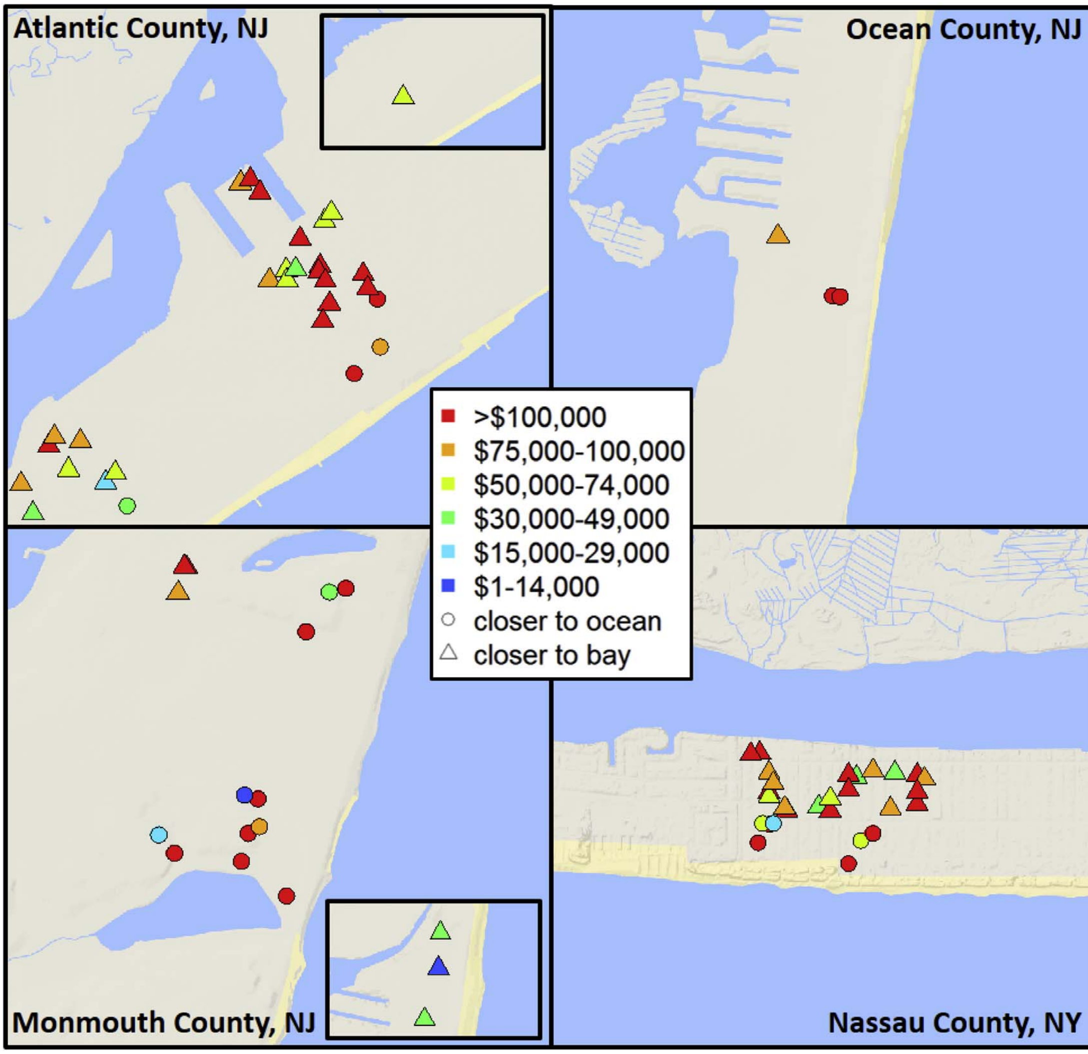

Fig. 5. The spatial distribution of surveyed locations at the four sampling areas showing the household income level (in color) and whether the household is closer to the bay or ocean (in shape). The figure shows only 78 sites due to 29 missing values for the income variable. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

less attention because they represent a more complex and dynamic system that is influenced by a broader set of considerations. Therefore, they are more difficult to study and implement develop of sound flood-prevention measures (Parry, 2017).

4. Conclusions

As accelerating sea level rise unfolds over the next several decades, decision makers and individual homeowners will be faced with difficult choices about threatened assets on the coast. Some coastal communities, housing blocks, and neighborhoods located on the inundation fringes will face the prospect of relocation as one solution. Further, the spatial reach of natural disasters due to urbanization and increasing interconnectedness and interdependencies between jurisdictions, infrastructure networks, and socioeconomic systems has been increasing since 1900, generating new systemic vulnerabilities in mature urban spaces like the State of New Jersey (Mitchell, 2009). This study provides some initial indicators about how proximity to the shoreline can influence coastal homeowners' perceptions of risk and willingness to participate in such programs post major disaster. In our study, the proximity to the shoreline represents a significant contributor to the relocation decision-making only among the survey participants living closer to the bay, where they are more likely to consider relocation if exposed to repetitive flooding and if offered an opportunity to participate in the buyout program. We also found that survey respondents living in households at the lower elevation were more concerned with the city rebuilding rules than those living at higher elevations. Other considerations were not significantly influential in the relocation decision-making process. We suspect that willingness to consider relocation is influenced by some other socioeconomic and qualitative factors rather than the physical location, especially after the experience with Hurricane Sandy devastation. Implications of varying risk perceptions to the proximity to shoreline include real-estate values and resale potential, investment in new housing and infrastructure, as well as support for hazard mitigation and adaptation interventions. This effort highlights the importance of scale and spatial distribution of residential properties in the proximity to hazard and warrants further more extensive exploration on what homeowners are willing to consider as an acceptable response strategy considering their specific location on different coastal landforms and in the proximity to hazard, as well as other urban features that may affect their sense of confidence and response need, like accessibility, evacuation, sheltering, and social support.

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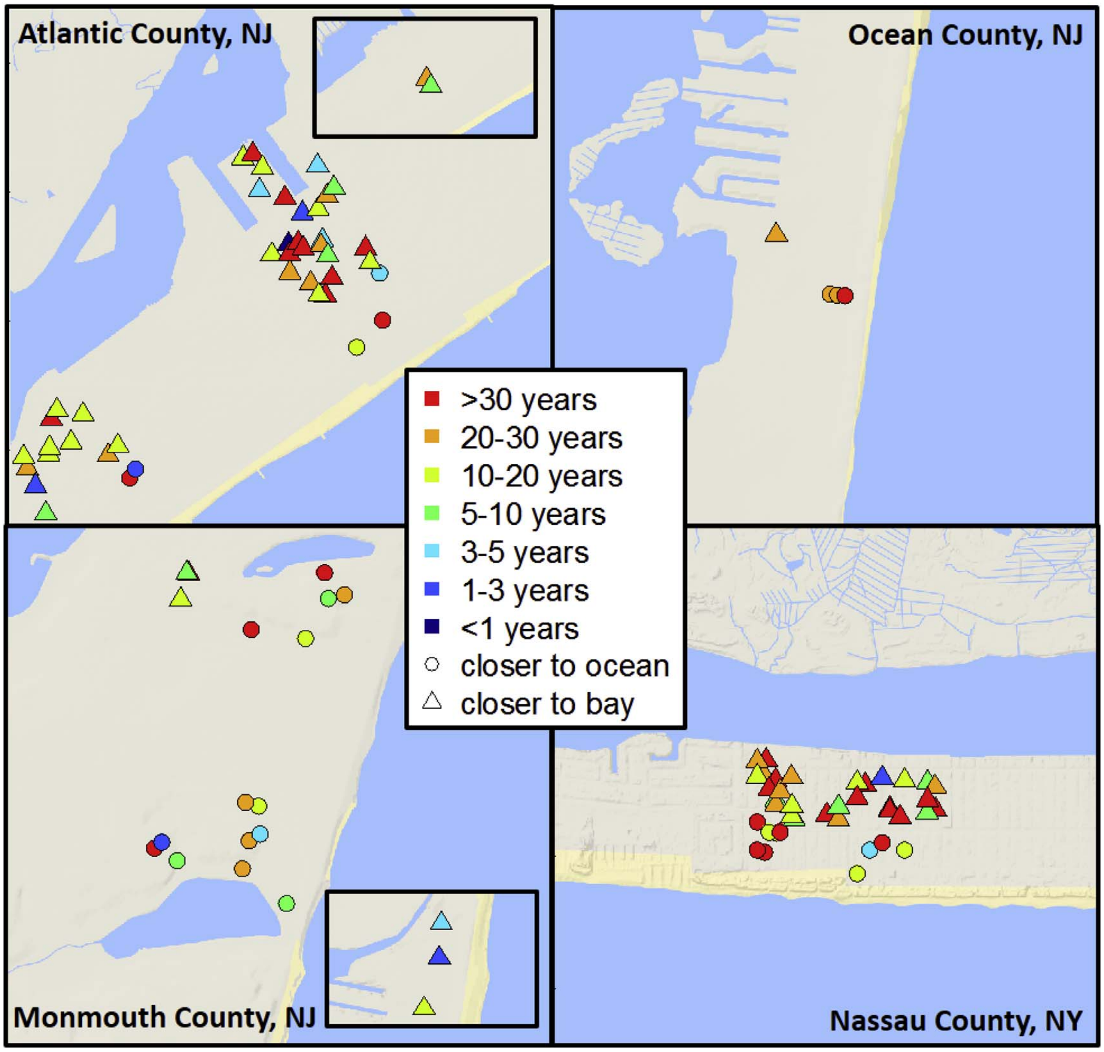

Fig. 6. The spatial distribution of surveyed locations at the four sampling areas showing for how long participants have lived in the household (in color) and whether the household is closer to the bay or ocean (in shape). The figure shows only 78 sites due to 29 missing values for the income variable. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2018.01.002.

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