Designing effective incentives for living shorelines as a habitat conservation strategy along residential coasts

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Abstract
Shoreline armoring is a pervasive driver of habitat loss and ecosystem decline along coastlines. Nature-based strategies for coastal protection, such as “living shorelines,” offer potential alternatives to armoring and are rapidly gaining traction among conservation scientists and practitioners. However, along residential coasts where armoring has often occurred at high rates, transitioning away from armoring has been generally slow. We studied the attitudes, beliefs, and decisions of waterfront homeowners with a goal of identifying effective incentives for living shorelines as a conservation tool for reversing coastal habitat loss. We show that while only 18% of homeowners with armored shorelines would willingly transition during a key window of opportunity, a modest economic incentive could increase the likelihood among 43% of all respondents and up to 61% of recent homeowners. Our study demonstrates potential pathways for navigating social, economic, and environmental influences on landowner decisions for coastal habitat conservation.

KEYWORDS
decision-making, ecological restoration, participatory conservation, shoreline armoring, social-ecological systems, urban landscapes

1 INTRODUCTION

Conserving biodiversity and sustaining ecosystem services in urbanized social-ecological systems (SES) demands understanding and often changing human behavior (Reddy et al., 2017; Schultz, 2011; Seto, Güneralp, & Hutyra, 2012). At the land-sea interface, natural coastal habitats such as saltmarshes, seagrasses, and oyster reefs are well recognized for supporting critical ecosystem functions and services (Barbier et al., 2011; Grabowski et al., 2012). Yet, along densely populated coastlines, residential and other forms of development have often involved the armoring of shorelines with artificial structures, such as vertical bulkheads and seawalls (NRC, 2007, 2014).
Shoreline armoring has been widely described as a major driver of coastal habitat loss and ecosystem decline by altering depth profiles, increasing wave climates, and disrupting land-water exchange (Bilkovic & Roggero, 2008; Douglass & Pickel, 1999; NRC, 2007). In the United States, 14% of all shorelines have been modified from their natural condition and replaced with artificial structures (Gittman et al., 2015). Furthermore, in areas with dense residential development, upward of 50–90% of shorelines can be armored, representing extensive losses of natural coastal habitats and the critical ecosystem functions they support.

More recently, however, research and innovation on nature-based approaches to coastal protection, such as “living shorelines,” have rapidly increased (Arkema, Scyphers, & Shepard, 2017; Bilkovic, Mitchell, La Peyre, & Toft, 2017). Living shoreline approaches aim to provide the wave buffering and erosion control functions desired of armored structures, while also maintaining, enhancing, or restoring the ecological benefits of natural coastal habitats (Davis, Currin, O’Brien, Raffenburg, & Davis, 2015; Gittman et al., 2016a; Piazza, Banks, & La Peyre, 2005; Scyphers, Powers, Heck, & Byron, 2011; Scyphers et al., 2015a). Empirical studies on living shorelines have generally found that they support higher biodiversity and related ecosystem services than vertical walls or degraded shorelines (Gittman, Scyphers, Smith, Neylan, & Grabowski, 2016b). This increased biodiversity may not only provide environmental benefits but may also promote sense of place and human well-being (Hausmann, Slotow, Burns, & Di Minin, 2016). However, the use of living shorelines for coastal protection has been slow to progress because of legacies of coastal habitat degradation, biophysical constraints on natural habitats (e.g., altered depth profiles and wave climates adjacent vertical walls), and largely unknown social and economic dimensions (e.g., risk perceptions, preferences, regulatory hurdles) (Abelson et al., 2016; Landry, 2011; Scyphers, Picou, & Powers, 2015b). Understanding these unknown dimensions, including the meanings, identities, and attachments associated with coastal habitats by residents, will help to better design conservation and management initiatives (Smith, Davenport, Anderson, & Leahy, 2011).

In the SES formed by waterfront residents and coastal ecosystems (Figure 1), reversing the feedback loops that lead to coastal habitat loss and degradation through shoreline armoring requires understanding the diverse social, economic, and environmental factors that influence the decisions of homeowners. Previous studies of waterfront resident decision-making have revealed that priorities for cost-effective and durable shoreline stabilization often outweigh environmental concerns and aesthetic preferences (Scyphers et al., 2015b; Smith et al., 2017). Of major conservation concern, these studies have also shown that a single
homeowner’s decision to install a bulkhead can trigger similar, reactive decisions by neighbors leading to cascading patterns of shoreline armoring and coastal habitat degradation. More broadly, residential landscapes provide an ideal SES for assessing how stakeholders perceive and prioritize ecosystem services, make decisions, and respond to incentives for achieving conservation objectives (Cook, Hall, & Larson, 2012; Larson, Casagrande, Harlan, & Yabiku, 2009; Larson, Cook, Strawhacker, & Hall, 2010; Lerman & Warren, 2011; Reddy et al., 2017). Here, we describe the results of a survey that evaluated shoreline management decisions, with an emphasis on designing effective incentives for living shorelines as habitat conservation along residential coastlines. First, we describe similarities and differences in coastal habitat-related attitudes and beliefs among waterfront homeowners with natural and armored shorelines. Second, focusing on homeowners with shorelines armored with vertical walls (e.g., bulkheads) and a hypothetical context of post-storm rebuilding, we identify the most powerful predictors of willingness to implement living shorelines with and without economic incentives.

2 | METHODS

2.1 | Study setting

Our study focused on a four-county region of the northern Gulf of Mexico adjacent Mobile Bay, Alabama and Pensacola Bay, Florida (Figure 2). Both systems represent estuaries typical of the southeast United States with historical legacies of shoreline armoring followed by more recent emphasis on habitat conservation and living shorelines. To quantify the recent extent of natural habitats and armoring in the region, we conducted a series of geospatial analyses using county tax databases for parcel-level data on residential properties and NOAA’s Environmental Sensitivity Index for shoreline condition. First, we mapped and calculated the overall percentages of vegetated, mud or sand, and armored shorelines throughout the study system (Figure 2; Table S2). We then calculated the percentage of all residential parcels comprised of each shoreline type within each county. These analyses showed that while 14% of all sheltered shorelines were armored, rates of residential armoring were considerably higher at 46–56% for Mobile Bay and 38–63% for Pensacola Bay (Figure 2).

2.2 | Survey design

Our 67-question survey instrument was developed and pretested by an interdisciplinary team of coastal scientists, conservation practitioners, and waterfront homeowners. Drawing from recent studies on the role of attitudes and beliefs in shaping environmental management preferences, specifically place-based meanings (Smith et al., 2011; Smith, Anderson, & Moore, 2012), a key series of questions in our survey measured beliefs in the importance of natural coastal habitats for individual and family identity, community identity, and community economy. Smith et al. (2011) defined individual identity as representing “the extent to which individuals believe the landscape informs their self-identity” and family identity as “the extent to which the landscape defines one’s belief about their family’s unique identity.” In our survey, “landscape” was defined as “natural coastal habitats,” and we combined individual and family identity into a single construct. Similarly, community identity represents the extent to which the landscape “contributes to local culture, character, and identity,” and community economy represents the extent to which the landscape “contributes to my community’s economy.” A two-question series on ecological beliefs focused on the importance of natural habitats and coastal processes.
coastal habitats for (a) healthy fish, shrimp, and crab populations and (b) protecting and improving water quality. This section also included questions to measure ecological concern (related to the degradation of coastal habitats) and erosion concern. The specific details of each concept are in Table 1 and Appendix 1.

A second core set of questions described in this paper focused solely on waterfront homeowners with vertical walls and their potential willingness to transition to a living shoreline in the hypothetical context of damage following a major storm (Table S1). First, all respondents with vertical walls were presented with a question assessing their willingness to implement living shorelines if their current structures were damaged beyond repair using a 5-point Likert scale from “Very Unlikely” to “Very Likely.” With the exception of those who selected “Very Likely,” respondents were then presented with the same proposal but with a financial incentive from an environmental organization, and their likelihood of implementation was reassessed. The hypothetical financial incentive was offered once as a percent-based cost-share randomly presented at 10% intervals (e.g., 10%, 20%, etc.).

The survey instrument also measured shoreline characteristics (current shoreline condition, legacy effects, neighboring shoreline condition), which can influence local wave climates, currents, and shoreline erosion experienced by homeowners. Natural shoreline categories included salt-marsh, sand/mud, and bluff. Armored shoreline categories included vertical wall, riprap revetment, breakwater, and groin. For artificial shorelines, legacy effects were documented through a question that asked if the shoreline was altered during the current or a previous ownership. Finally, the survey included questions to document gender, age, annual household income, education, environmental dependence, and years lived at current residence.

2.3 Survey data collection

We conducted a mixed-mode survey (online, mail). Waterfront homes were randomly selected using Google Earth Pro and county tax assessor websites. Properties that had been listed or sold during the previous 12 months were excluded. Participants were recruited using a modified Dillman approach (Dillman, Smyth, & Christian, 2014) involving an initial mailing of postcard invitations to complete an online survey and three follow-up reminders. Printed surveys were mailed to 20% of the sample and
all individuals who requested them. The online survey was hosted and administered using Qualtrics Research Suite, which also served as the database for mail-returned surveys. The survey had an adjusted response rate of 21%, mean completion rate of 83%, and median completion time of 20 minutes for the online version.

2.4 | Analyses

We used multivariate and univariate statistics to evaluate relationships among waterfront homeowners’ attitudes, beliefs, and decisions on shoreline management. First, we applied Mann–Whitney U tests to determine if responses differed across respondents with natural versus armored shorelines. Next, we used tree-based classification models using the chi-squared automatic interaction detection (CHAID) growing method to evaluate which factors were most predictive of a waterfront homeowner’s stated likelihood of implementing a living shoreline (without and with incentive). The CHAID method identifies the independent variable with the strongest interaction at each step of the process and merges categories that are not significantly different with respect to the dependent factor. Scale variables (e.g., age, years at current residence) are automatically banded into discrete groups prior to the analysis. The tree models considered two scale variables (age, years at current residence), five nominal or binary variables (education, geographic zone, neighboring shoreline condition, environmental dependence, shoreline legacy effect) and seven ordinal variables (individual and family identity, community identity, community economy, ecological beliefs, ecological concern, erosion concern, income category). For the analyses with the cost-share incentive, we calculated a categorical “incentive effect” as the difference in Likert values with and without incentives. To directly test for a potential effect of cost-share amount (binned in 20% intervals), we used Kruskal–Wallis tests.

Nonresponses were not included in the analyses. For all tests, \( P \leq .05 \) was considered statistically significant and \( P \leq .10 \) marginally significant. All tests were computed using the Statistical Package for the Social Sciences (SPSS), Version 23.

3 | RESULTS

3.1 | Sample and property characteristics

Our survey sample included 181 waterfront residents near Mobile Bay, Alabama \( (n = 96) \) and Pensacola Bay, Florida \( (n = 85) \). Compared to demographics of the broader coastal counties, the survey sample of waterfront residents had a higher proportion of males (63%), college graduates (mode: 75% bachelor’s degree or above), higher household incomes (mode: 53% greater than $100,000), and older (mean: 65 years old) individuals. Residents, on average, had spent 22 years living on the water. Overall, one-third of respondents reported their shoreline condition as natural or unaltered, whereas 67% reported armored shorelines. Among residents with armored shorelines, 60% reported owning when alterations were made, and 94% were neighbored by other armored shorelines. Among residents with natural shorelines, 44% were neighbored by armored shorelines. The full survey demographics are in Appendix 1.

3.2 | Attitudes and beliefs on the importance of coastal habitats

A primary goal of our study was to assess how homeowners with differing shoreline types perceived the natural coastal habitats that traditionally border coastlines (Table 1). Perceived linkages between coastal habitats and individual and family identity was significantly higher among homeowners with natural shorelines (67%) than those with armored shorelines (45%). Perceptions that natural habitats are important for water quality were more common among homeowners with natural (72%) than armored (51%) shorelines. Concern for coastal erosion differed by shoreline type with 61% of natural shoreline homeowners versus 78% of armored shoreline homeowners very to extremely concerned. Homeowners across both shoreline categories perceived a link between coastal habitats and their community’s economy (38–47%). A majority of all homeowners recognized the ecological importance of natural habitats for healthy fish, shrimp, and crab populations (68–76%) and were very to extremely concerned about the habitat loss and degradation (70–80%).

3.3 | Shoreline decisions and incentives for habitat conservation

A second goal of our study focused on understanding the overall likelihood and most powerful predictors of homeowners’ willingness to implement living shorelines. We found that only 18% of residents with vertical walls would be likely to adopt a living shoreline technique without additional incentives (Figure 3). Classification tree analyses revealed that homeowners who considered natural habitats important for their community’s identity and those most concerned with erosion were the most likely to adopt living shorelines.
FIGURE 3  Results of a classification tree analysis to determine the most powerful predictors of initial (without incentive) likelihood of a homeowner choosing a living shoreline if their structure was damaged beyond repair. The graphs shown for each node represent the percent response for each response category from “Very Unlikely” (far left) to “Undecided” (middle white) and “Very Likely” (far right). Separate branches indicate statistical differences at $P \leq .05$.

When homeowners who initially stated less than “Very Likely” were subsequently offered a cost-share, the percentage likely to choose living shorelines increased to 30%, a 67% proportional increase (Figure 4a). Overall, the presence of a cost-share had a positive effect on 42.5% of participants. Notably, the generally positive effect of the cost-share was statistically similar across all percentages offered, indicating that the amount of cost-share did not substantially influence decision-making (Figure 4b; $H = 1.43$, df = 4, $P = .84$). Using classification tree analyses, we found that the strongest predictor of cost-share effectiveness was years in current home with 60.5% of more recent residents (14 years or less in current home) likely to implement a living shoreline compared to 26.2% of longer-term residents (Figure 5). Among longer-term residents, the hypothetical economic incentive positively influenced 30.6% of residents who were most concerned with coastal erosion. Similarly, among this group, the hypothetical incentive positively influenced 39.3% of residents who perceived natural coastal habitats as important for their community’s economy.

4 | DISCUSSION

As a strategy for restoring coastal habitats and achieving conservation objectives along urbanized coasts, living shorelines offer promising alternatives to traditional armoring (e.g., Davis et al., 2015; Gittman et al., 2016a; Scyphers et al., 2011). However, the uptake of living shorelines among waterfront homeowners has been slow and impeded by numerous challenges and unknowns. Through a better understanding of waterfront homeowners’ attitudes, beliefs, and decisions, our study reveals key opportunities and pathways for incentivizing living shorelines as a tool for habitat conservation. For instance, our results demonstrate how individual attitudes and beliefs associated with healthy natural habitats are an important basis for understanding and motivating shoreline management decisions. Likely most important for conservation success, our results also indicate that even small economic incentives can alter homeowner decisions and be bolstered by an understanding of social influences.
A key finding of our study is that the degree to which waterfront homeowners link natural coastal habitats to their individual, family and community identity differs among homeowners with natural and armored shorelines. Previous studies of place meanings, including the concepts of family identity and community identity, have shown that natural habitats and the places in which they occur can promote strong bonds between people and nature, and ultimately contribute to desired management outcomes (Haussmann et al., 2016; Smith et al., 2011, 2012). In this context, our findings have important implications for conservation planning and practice as beliefs about community identity provided the strongest predictor of initial support for living shorelines. Another key finding of our study is that a potential cost-share program could increase overall likelihood of living shorelines implementation among 43% of all respondents and up to 61% of more recent homeowners. Cost-share programs aimed at promoting living shorelines have been active in the Chesapeake Bay regions of Maryland and Virginia for years (Davis & Luscher, 2006). Yet, the transfer of these strategies to other places has been limited compared to upland settings where programs are more common and have been funded by nonprofit organizations, government agencies, and extension programs.

Considering the strong influence of adjacent shorelines on homeowner decisions (Scyphers et al., 2015a,b), incentivizing or “nudging” individual decisions could have major conservation benefits through positive feedbacks or collective action (Reddy et al., 2017). Studies of residential landscape management in other ecosystems have also demonstrated similar patterns of clustering, where individual decisions appear strongly influenced by neighboring and community settings (Hunter & Brown, 2012; Larson et al., 2009). For instance, green infrastructure studies have found that residents are more likely to have gardens if other residents in their viewshed also have gardens (Hunter & Brown, 2012). With waterfront residents, however, the scenario is potentially more complex as neighboring shorelines also have biophysical influences through increased wave energy and worsened erosion. Therefore, conservation practitioners must understand both the social and biophysical environments of coastal waterfront properties to maximize success and incentivize living shorelines as a strategy for coastal habitat conservation.

The conservation context of our study is important for at least three reasons. First, storms are a common disturbance for coastal waterfront residents and motivate many homeowners to install, repair, or replace armored structures like bulkheads (Smith et al., 2017). Considering that storms also often trigger substantial restoration funding, our study focuses on an important window of opportunity for simultaneously pursuing residential recovery and conservation objectives. Second, vertical walls are often considered the most ecologically harmful approach to coastal shoreline management (Bilkovic & Roggero, 2008; Douglass & Pickel, 1999; Gittman et al., 2016a,b; Scyphers et al., 2015a); thus, focusing on replacing vertical walls would align with conservation ideologies of mitigating or reversing the most detrimental practices first (Schultz, 2011). Finally, considering the wide socioeconomic gaps between waterfront property owners and coastal communities more generally, coupled with the recognition that armored structures can severely degrade coastal ecosystem services, residential shoreline management decisions may represent an unrecognized environmental justice issue for conservation practice to pursue.

For coastal systems on a continuing trajectory of urbanization, increasing populations, and habitat loss, recent advances in living shorelines and conservation planning tools are promising strategies for reversing ecosystem degradation and biodiversity declines. Living shorelines have become widely recognized for achieving better...
FIGURE 5  Results of a classification tree analysis to determine the most powerful predictors of cost-share effectiveness. Separate branches indicate statistical differences at $P \leq .05$. 

Overall

- More Likely: 42.5%
- No Effect: 52.5%
- Less Likely: 5.0%

Years in Current Waterfront Home

(N = 80)

14 or Less

- More Likely: 60.5%
- No Effect: 36.8%
- Less Likely: 2.6%

15 or More

- More Likely: 66.7%
- No Effect: 26.2%
- Less Likely: 7.1%

Erosion Concern

(N = 42)

2 or Less

- More Likely: 66.7%
- No Effect: 33.3%

3 or More

- More Likely: 66.7%
- No Effect: 30.6%
- Less Likely: 2.8%

Community Economy

(N = 36)

Strongly Disagree to Neutral

- More Likely: 87.5%
- No Effect: 12.5%

Agree to Strongly Agree

- More Likely: 39.3%
- No Effect: 60.7%
ecological outcomes than traditional armoring (NRC, 2007), and they may also be more resilient during storm events (Gittman, Popovich, Bruno, & Peterson, 2014; Smith, Puckett, Gittman, & Peterson, 2018). While the delivery of specific services will certainly vary across space and time (Koch et al., 2009), the potential for living shorelines to benefit people and nature is clear (Arkema et al., 2017). However, as with most effective conservation initiatives, implementation strategies must align with stakeholder attitudes, beliefs, and priorities (Armstrong & Steadman, 2012; Reddy et al., 2017).

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DATA STATEMENT

All survey instruments, protocols, and metadata are publicly available at Northeastern University’s Digital Repository Service: http://hdl.handle.net/2047/D20213516.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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