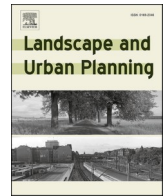


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Research Paper

## Marshes to mangroves: Residential surveys reveal perceived wetland trade-offs for ecosystem services

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## HIGHLIGHTS

- Shoreline landscapes are important yet understudied social-ecological systems.
- Social valuation of shoreline habitat ecosystem services in Gulf of Mexico, USA.
- Surveyed 530 waterfront residents on relative performance of mangroves vs. marshes.
- Geography, local environment, individual attitudes, and behaviors drove perceptions.
- Social data needed to predict coastal landscape shifts under climate change.

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## ABSTRACT

Coastal landscapes are rapidly changing due to both climate change and the decisions of waterfront landowners. For instance, the climate-driven encroachment of woody mangrove species into grassy marshland areas is predicted to impact coastal ecosystems, with consequences for the ecosystem services these landscapes provide to people. However, there is a dearth of knowledge concerning coastal resident perceptions of the effects of mangrove expansion on wetlands and their ecosystem services, which may impact residents' behavior around shorelines and landscape-level patterns. We surveyed waterfront residents in the northern Gulf of Mexico (USA) to understand perceptions of the relative performance of marshes and mangroves to deliver fisheries ecosystem services. Residential-scale shoreline condition and preference, recreational fishing activity, geography, and demographics were evaluated as potential predictors of resident perceptions through non-parametric comparisons across groups and ordered logit modeling. Significant predictors included area of residence, marsh shoreline condition, marsh shoreline preference, fishing frequency, and household income. Florida residents (where mangroves are most prevalent) and frequent recreational fishing participants exhibited stronger preference for mangroves. Unexpectedly, residents with marsh currently present on their shoreline also perceived that mangroves were better at delivering fisheries ecosystem services than marshes. Considering the important role that coastal residents play in shoreline management decisions, these results demonstrate how coastal resident attitudes may drive or mediate climate-driven processes in ways that are not evident by examining environmental conditions alone. Understanding social-ecological shifts due to climate change will be important to inform effective landscape management that promotes resilience in coastal ecosystems and societies.

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## 1. Introduction

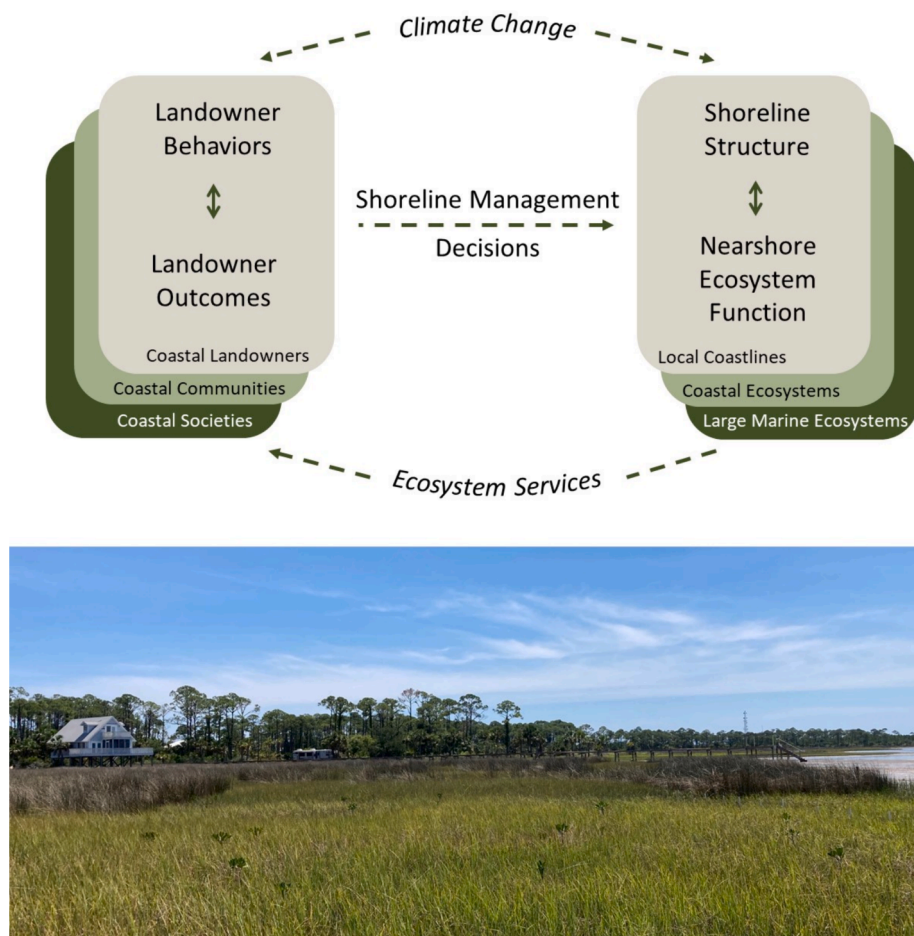
Coastal regions face social-ecological challenges at multiple scales that may impact ecosystem service delivery in the face of environmental change. On a global scale, coastal ecosystems and societies are threatened by interacting biophysical and social forces such as natural hazards and warming temperatures, habitat loss and degradation, and population growth and development (Peterson et al., 2008; Pereira et al., 2012; Moorman et al., 2023). These interacting stressors are altering ecosystem structure, which affects ecosystem functioning, and the resulting ecosystem services provided to coastal communities (MEA, 2005). Along coastlines, this is particularly important because a disproportionate share (27% of the global population) resides within 100 km of a coastline (Reimann et al., 2023). Ecosystem service production from habitats in estuarine and coastal zones include critical services such as water filtration, carbon sequestration, protection from erosion and extreme event damage, and provision of nursery habitats for viable fisheries (MEA, 2005).

In local systems, people are not only subjected to ecological and social change, but they are also actors who drive change in their community (Fig. 1). At the scale of an individual property, waterfront residents directly manage and alter their shoreline to achieve social goals, and thus can exert exceptional individual power over shoreline composition in comparison to other coastal residents (Scyphers et al., 2015; Pace, 2017). Waterfront residents evaluate trade-offs among shoreline types for their capacity to deliver services such as coastal protection, navigation of waterways, aesthetic value, and recreation (Scyphers et al., 2019; O'Donnell et al., 2022). More broadly, residential

and landscape decisions are also impacted by the social and cultural norms of residents' neighbors (Nassauer et al., 2009; Lerman et al., 2012; Scyphers et al., 2015). When waterfront residents are subjected to shifting ecological and social conditions on their property or in their area of residence, changes in ecosystem service production may alter residents' decision-making processes and resulting behaviors along their shorelines (Scyphers and Lerman, 2014).

Importantly, few studies examining ecosystem service perceptions specifically operate within the context of ongoing and expected shoreline change, despite dramatic observed shifts in shoreline composition (Felipe-Lucia et al., 2015). Some studies have compared ecosystem service perceptions for natural vs. hardened shorelines in the context of shoreline armoring (Scyphers et al., 2015; Gray et al., 2017; O'Donnell et al., 2022; Strain et al., 2022), but few studies have investigated ecosystem service perceptions under habitat range shifts driven by climate change. To address this gap, we conducted our study in a part of the world where warming winter temperatures are enabling the range expansion of mangrove forests into salt marshes, which is resulting in a shift in the ecological and societal benefits provided by coastal wetlands (Hagger et al., 2022).

Salt marshes and mangroves are productive and highly valued wetland habitats that sequester carbon, control erosion, protect communities from storms, improve water quality, provide habitat, support fisheries, and offer recreational opportunities (Barbier et al., 2011). Historical perceptions of wetlands are fraught with deprecation; for example, colonial accounts of mangroves focus on ecosystem disservices such as disease and pests, though some highlight their provisioning capacity for fisheries (Friess, 2016). Perceptions of wetlands in the



**Fig. 1.** Components of and linkages within coastal social-ecological systems influenced by climate-driven nearshore habitat change (above), and a photo evidencing mangrove expansion on waterfront property in northwest Florida, USA (below). Modified with permission from Scyphers et al. 2020.

present-day are generally characterized with awareness of their benefits but these vary substantially by environmental and social context (Dencer-Brown et al., 2019; Friess et al., 2020; Su and Gasparatos, 2023). For example, Interis and Petrolia (2016) used an economic choice experiment to compare four coastal habitats in the southeastern United States and found few differences in willingness to pay for multiple ecosystem services derived from salt marshes and mangroves. Regime shifts in dominant coastal plant communities are being observed globally as tropical mangroves expand poleward and salt marshes contract due to reductions in winter freeze frequency and intensity. These mangrove expansion zones will experience impacts to ecosystem functions, services, and perceptions that are locally determined and context-specific (Kelleway et al., 2017; Osland et al., 2022).

Few studies to date have quantified coastal resident perceptions comparing fisheries ecosystem service delivery under present vs. projected habitat scenarios. One dominant mechanism for the contribution of coastal habitats to fisheries is as nurseries for valued fish stocks (Beck et al., 2001; Whitfield, 2017; Lefcheck et al., 2019). The relative importance of mangroves and salt marshes for fisheries productivity has been studied empirically, but findings are mixed (Kelleway et al., 2017; Osland et al., 2022). In general, existing literature suggests that species composition may differ between these habitats, but this varies substantially depending on the taxonomic group studied and environmental context (Saintilan, 2004; Smeed et al., 2017; Armitage et al., 2021). There is a stronger body of evidence demonstrating that the provisioning capacity of wetlands for underpinning coastal fisheries is supported by heterogeneous and complex coastal habitats in the seascape (Nagelkerken et al., 2013; Sheaves et al., 2015). Fisheries support is also an ecosystem service that is routinely mentioned, ranked highly, and understood among studies of perceptions of ecosystem services, and thus serves as a direct motivational link influencing waterfront resident behavior (Martín-López et al., 2012). As climate change shifts the distribution of wetlands and fish species, fisheries harvest and recreational opportunities will also change (Pinsky and Fogarty, 2012; Townhill et al., 2019). This has particular implications for waterfront resident perceptions and behavior because these residents control the shoreline composition (and thus potentially the fish community) along their property. These residents may also see impacts of these changes through fishing in their local coastal system more broadly. Interestingly, limited research suggests that fishing access and behavior are different for waterfront property owners in comparison to other coastal fishermen (Ashford and Jones, 2010), so the perceived influence of shoreline type on fisheries ecosystem services for this understudied demographic could provide information on decision drivers.

This study used social valuation of fisheries ecosystem services to compare preferences at such a granular scale to parse the perceptions of marsh and mangrove species in a regional transition zone. Techniques for social valuation of ecosystem services have advanced in recent years (Martín-López et al., 2012; Hicks and Cinner, 2014; Quintas-Soriano et al., 2018; Su and Gasparatos, 2023) in response to criticism over limitations to traditional biophysical or economic approaches (Kumar and Kumar, 2008). Importantly, social valuation of ecosystem services should not be conflated with valuation of cultural ecosystem services which are nonmaterial benefits and a specific type of entity being valued, whether in monetary or non-monetary terms (Felipe-Lucia et al., 2015; Chan et al., 2012). In contrast, social valuation describes a method involving compiling the perceptions of relevant parties through identification and ranking of preferences of ecosystem services within their landscape (Felipe-Lucia et al., 2015; Hirons et al., 2016). The first aim of this study was to use social valuation to quantify perceptions of two coastal habitats in the context of their relative performance for fisheries ecosystem service delivery. The second aim of this study was to identify predictors relating to geography, residential-scale shoreline conditions and attitudes, recreational fishing activity, and demographics that are influential in explaining these perceptions.

## 2. Methods

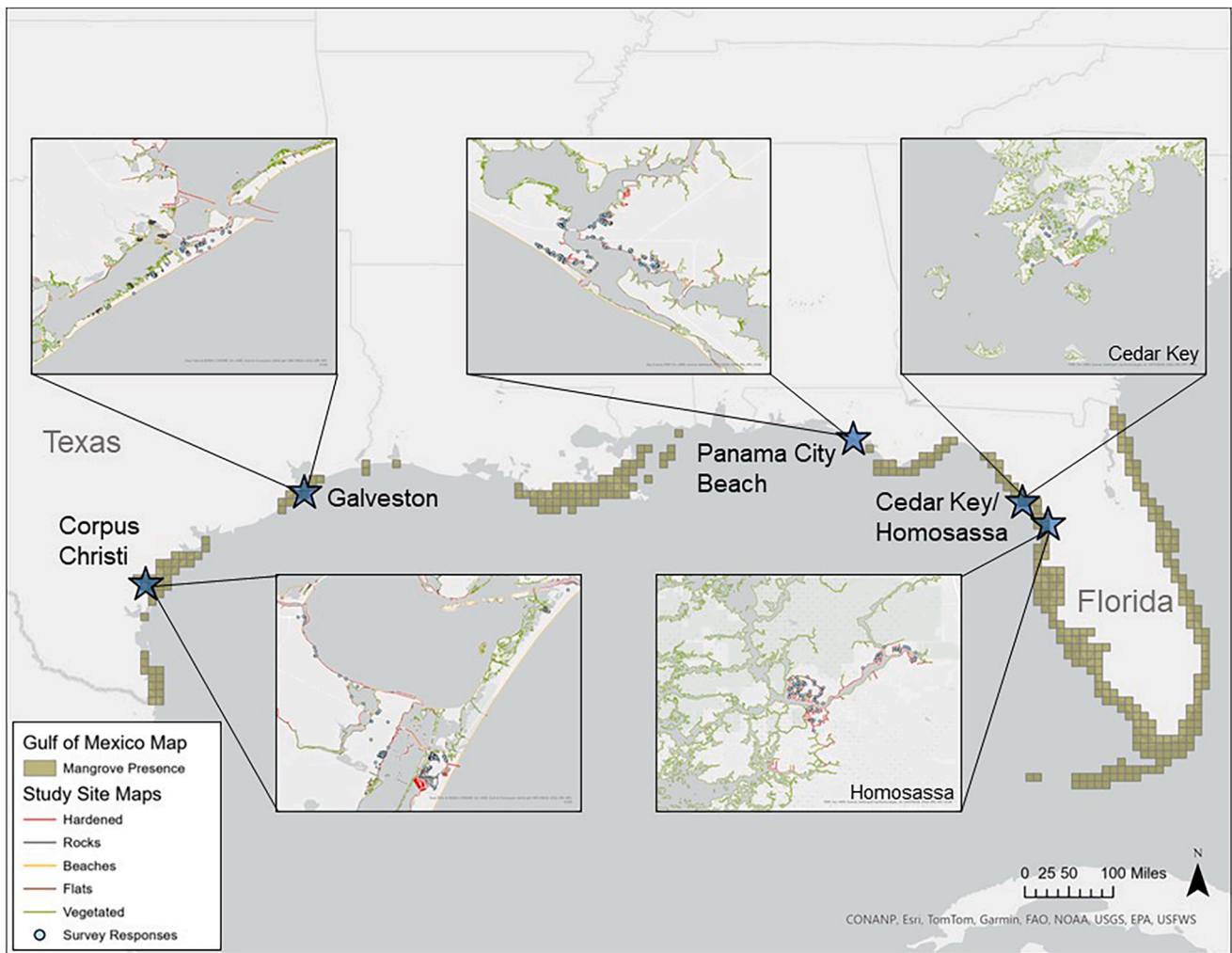
### 2.1. Study setting

This study was conducted in the northern United States Gulf of Mexico (GoM, USA; Fig. 2) as this region is experiencing climate-induced and societally-driven habitat shifts. The GoM is a complex social-ecological system containing industries and communities reliant on the biodiverse coastal and marine ecosystems of the region (Cato, 2008; Shepard et al., 2013; Swinea and Fodrie, 2021). For example, GoM fishing and seafood industries are crucial for economic prosperity and regional identity. In 2020, these industries contributed forty percent of the nation's domestic fish products, produced over \$25 billion in sales, employed over 150,000 people, and supported over fifty-five million recreational fishing trips (NMFS, 2022).

Wetland habitats such as salt marshes and mangrove forests comprise over one-third of GoM shorelines (Gittman et al., 2015) and are important for structuring nearshore communities and determining the functional capacity for coastal ecosystems in the region (Zedler and Kercher, 2005). While mangrove forests are tidal saline wetlands dominated by woody plants, salt marshes are tidal saline wetlands dominated by grass-like plants. Mangroves are most abundant in warmer, southern portions of the GoM because they are killed by extreme cold temperatures. In contrast, salt marsh plants, which can tolerate cold temperatures, are more abundant in colder, northern portions of the GoM. Mangroves have been present in Florida, Louisiana, and Texas for many centuries (Sherrod and McMillan, 1985). However, warming winter cold temperature extremes are contributing to the northward range expansion of mangroves, which are replacing salt marshes in parts of northwest Florida, Louisiana, and Texas (Osland et al., 2013; Saintilan et al., 2014; Osland et al., 2017a; Osland et al., 2021; Bardou et al., 2023). All three of the most common species of mangroves native to the region (i.e. black, *Avicennia germinans*; red, *Rhizophora mangle*; and white, *Laguncularia racemosa*) occur in Florida as far north as Cedar Key (Davis, 1940). However, black mangroves and red mangrove individuals have been expanding in the northern Florida panhandle in the Apalachicola area (Snyder et al., 2022). In Texas, black mangroves have been present since at least the early 20th century based on historical records (Sherrod and McMillan, 1981). In Southern Texas, mangroves have increased in abundance beginning in the 1930s but were likely present before then (Sherrod and McMillan, 1981). More northern areas in Texas such as Galveston County saw its first black mangroves in the early 1980s (Sherrod and McMillan, 1981). The last region-wide winter mortality event that resulted in widespread mangrove damage occurred in 1989, and mangrove expansion has occurred to different extents across the region since then (Osland et al., 2017a; Bardou et al., 2023). In addition to these changes in wetland flora caused by mangrove expansion into salt marsh, climate-induced changes in macrofaunal community composition and abundance have already been observed in the northern GoM (Fodrie et al., 2010; Pinsky et al., 2013; Osland et al., 2021), with impacts already felt through ecosystem services like fisheries landings (Karnaukas et al., 2015). Thus, mangrove expansion on coastal properties may have unprecedented consequences for ecosystem services and shoreline decision-making for coastal residents in the region.

### 2.2. Survey data collection

The study survey instrument was deployed from fall 2021 to fall 2022 with the specific aim of social valuation and understanding the interplay of perceptions of coastal habitats and their fisheries ecosystem services with geographic, environmental, attitudinal, behavioral, and demographic predictors. US GoM waterfront property owners constitute the sample frame for this study because of their direct coastal access, derivation of ecosystem services on a parcel scale, and capacity to impact shoreline composition. Four study sites in the northern GoM



**Fig. 2.** Map of mangrove presence as well as survey respondents and shoreline conditions in study sites across the northern Gulf of Mexico (USA). On the Gulf of Mexico map, the dark green squares represent mangrove presence. On the inset maps, the blue dots represent the locations of survey respondents. Cedar Key and Homosassa, Florida were combined to achieve a similar sample size of waterfront homeowners as in other study areas. The shoreline types include the following five categories: hardened (seawalls or other vertical structures), rocks (rocky and steep shorelines), beaches (sand/gravel), flats (mud/sand), and vegetated (grass/marsh/mangroves/scrub-shrub). Mangrove presence data are from [Bardou et al. \(2022\)](#), and shoreline data are from NOAA ESI ([NOAA, 2005](#)). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

were targeted: on the eastern Gulf, Cedar Key / Homosassa, and Panama City Beach, Florida (FL); and on the western Gulf, Galveston and Corpus Christi, Texas (TX) ([Fig. 2](#)). Cedar Key and Homosassa, Florida were combined to achieve a similar sample size of waterfront homeowners as in other study areas. Cedar Key / Homosassa, FL has established mangroves that are increasing in abundance; in contrast, Panama City Beach, FL does not yet have any established mangroves, but conditions are becoming more favorable for mangroves to colonize and proliferate ([Bardou et al., 2023](#)). Corpus Christi, TX has a longer history of mangrove presence than Galveston, TX, but both study sites experience frequent winter freeze events that can drastically alter mangrove coverage ([Armitage et al., 2015](#); [Kaalstad et al., 2024](#)). In summary, Cedar Key / Homosassa, FL, and Corpus Christi, TX are located within the current range of established mangroves in this region, while Panama City Beach, FL and Galveston, TX fall within projected mangrove expansion hotspots ([NOAA, 2005](#); [Bardou et al., 2022](#)). A stratified, random sample of 3200 residential waterfront addresses (800 addresses from each of the four study sites) was selected using county public property records. Residents were targeted using a mixed-mode survey in three mailings following a modified “tailored design method” ([Dillman et al., 2014](#)). Surveys that were returned to sender and properties that had been listed for sale in the preceding year were filtered out to produce an adjusted response

rate of 20.9% (n = 530 responses).

### 2.3. Survey design

The survey instrument collected information on perceived relative performance of marsh and mangrove habitats for supporting coastal fisheries, recreational fishing activity, shoreline condition and preference, and demographics (see [Supplementary Material](#) for the full survey instrument). The primary response variable evaluated in this study was the perceived relative performance of marshes and mangroves for supporting coastal fisheries. Before respondent perceptions were quantified, respondents were shown a screening question that assessed their familiarity with mangroves. Respondents who were not familiar with mangroves were not prompted to proceed with subsequent questions, and any such responses were excluded from analyses. Respondents were asked how they would rate the relative difference in marshes and mangroves for supporting coastal fisheries on a five-point scale (*Mangroves are Much Better*, *Mangroves are Slightly Better*, *No Difference*, *Marshes are Slightly Better*, or *Marshes are Much Better*).

Respondents provided the number of years they had lived on the waterfront and indicated frequency of recreational fishing activity on a six-point ordinal scale (*Never*, *Less than once per year*, *Yearly*, *Monthly*,

Weekly, and Daily). Respondents who had gone saltwater fishing in the last year reported fishing experience in years and fishing locations (*From Shore, Inshore, and/or Offshore*) in the last year. Respondents indicated their current shoreline condition by selecting one or more shoreline options that can be classified as natural (*Beach, Dunes, Mangrove, Marsh*) or hardened (*Bulkhead or Vertical Wall, Dock, Groin, Offshore Breakwater, Rocks or Rip-Rap Revetment*). Respondents were also asked to specify their ideal desired shoreline condition(s) out of these options, which represents respondent shoreline preference. General shoreline condition (*Hardened, Hybrid, or Natural*) for a residence was coded based on the more specific shoreline condition(s) reported by the respondent. Demographic information included birth year, gender, race/ethnicity, highest level of education, household income in 2020, and political affiliation.

#### 2.4. Analyses

Multivariate, univariate, and descriptive statistics were employed to understand drivers of environmental perceptions of our waterfront resident sample. All statistical analyses were performed in R Version 4.2.3 (R Core Team, 2023). Demographic, shoreline, and recreational fishing characteristics were summarized for the entire sample as well as by study site. All error terms following means are standard errors. The difference in shoreline condition across study sites was tested using a Fisher's exact test. Differences in perceived relative performance of marshes and mangroves for fisheries ecosystem services was tested using the Mann-Whitney *U* test across state of residence. The Kruskal-Wallis test (or one-way ANOVA on ranks) was used to compare perceived relative performance for fisheries ecosystem services across study site, mangrove or marsh shoreline condition (presence/absence), shoreline attitudes expressed as desired mangrove or marsh shoreline (desired/not desired), frequency of recreational fishing, and fishing location. Dunn's test with the Bonferroni adjustment was applied to significant results post hoc as a multiple comparisons procedure using the FSA package (Ogle et al., 2023).

Regression analyses were performed to evaluate the influences of recreational fishing activity, shoreline condition and preference, and demographics for determining perceptions of relative performance of marshes and mangroves for fisheries ecosystem services. The response variable was the perceived relative performance of mangroves vs. marshes for supporting coastal fisheries (measured on the 5-point scale). Potential predictor variables included state of residence, study site, years living waterfront, frequency of recreational fishing, general shoreline condition (hardened, hybrid, or natural), mangrove or marsh shoreline condition (presence/absence), and desired mangrove or marsh shoreline condition (desired/not desired). During model specification, predictor variables were evaluated for multicollinearity using variance inflation factors (VIFs), and sufficient multicollinearity was observed to necessitate removing state of residence and general shoreline condition from the regression. Demographic variables (birth year, gender, household income, highest level of education, and political affiliation) were also introduced as covariates. Missing values among variables were excluded using casewise deletion. In addition, the proportion of non-white respondents was low enough that there were not sufficient observations to include a race/ethnicity variable in analyses.

Analyses were performed using an ordinal logistic regression modeling approach, which is commonly applied for modeling ordered category outcomes (Heeringa et al., 2017). The specific modeling approach was a cumulative logit proportional odds model, which uses cumulative probabilities to specify logit functions and produce regression parameters for each predictor variable. The model was assessed using the proportionality (or parallel lines) assumption using the Brant-Wald test (brant package in R) (Schlegel, 2022), and passed this goodness-of-fit measure. The model was also subjected to the log-likelihood ratio test and the null hypotheses was rejected ( $p < 0.001$ ), indicating acceptable model fit. These analyses were performed using

the VGAM package in R (Yee, 2010).

Parameter estimates can be interpreted similarly to estimates in other regression techniques, where positive values signify increases in the probability of higher-ordered response categories for increases in the corresponding predictor variable. In the context of this study, positive estimates correspond to increasing probability of marsh preference, and negative estimates correspond to increasing probability of mangrove preference. Odds ratios are calculated as the exponentiated coefficients and show the change in the odds of landing in a higher category of the response variable for a one-level increase in that predictor variable. For this study, odds ratios exceeding one suggest increased probability of marsh preference for an increase in the predictor variable, where odds ratios falling below one suggest increased probability of mangrove preference for an increase in that predictor variable. Interpretation of model results for categorical predictor variables involves the comparison of a control or dummy level of that predictor variable to the other levels of that variable.

### 3. Results

#### 3.1. Demographics and residential-scale characteristics

The proportion of responses from each study site was as follows: 23.8% ( $n = 126$ ) in Cedar Key / Homosassa, 27.0% ( $n = 143$ ) in Panama City Beach, 27.9% ( $n = 148$ ) in Galveston, and 21.3% ( $n = 113$ ) in Corpus Christi. The majority of respondents were white (85.1%,  $n = 451$ ), and men represented slightly more than half of the sample (58.1%,  $n = 308$ ) (Table S1). Respondents were on average  $66 \pm 1$  years old. The highest level of education among respondents was most often a bachelor's degree (35.3%,  $n = 187$ ) followed by a master's degree (21.9%,  $n = 116$ ); almost three-quarters of the sample had received at least a bachelor's degree. The most frequently chosen 2020 household income category was more than \$250,000 (22.8%,  $n = 116$ ). Across all study sites, over 85% of respondents fell into income categories above the median income level for their county (United States Census Bureau, 2019), which is consistent with other studies of waterfront residents (Scyphers et al., 2015, 2020; O'Donnell et al., 2022).

Respondents had lived on the water for an average of  $21 \pm 0.8$  years. Respondents most frequently reported a bulkhead or vertical wall as a part of their shoreline (57.0%,  $n = 302$ ). Marshes were present on 28.1% ( $n = 149$ ) of respondent shorelines, and mangroves were present on 12.8% ( $n = 68$ ) of shorelines. The proportions of natural, hybrid, and hardened shorelines reported by respondents were significantly different across study sites ( $p = 0.004$ ). Cedar Key / Homosassa, FL respondents had the highest proportion of natural shorelines (16.7%) and the lowest proportion of hardened shorelines (39.7%), and Corpus Christi, TX respondents had the lowest proportion of natural shorelines (2.7%) and the highest proportion of hardened shorelines (54.0%). All study sites had similar proportions of hybrid shorelines. The presence of mangroves and marshes on respondent shorelines also differed when disaggregated by study site. Respondents reported mangrove presence on their shoreline in all study sites, but to varying extents: 46.8% of respondents in Cedar Key / Homosassa, FL reported mangroves, followed in frequency by Corpus Christi, TX (6.2%), Panama City Beach, FL (0.7%), and Galveston, TX (0.7%). Marsh presence along respondent shorelines was more consistent across the study sites than mangrove presence; 41.3% of Cedar Key / Homosassa, FL respondents reported marshes on their shoreline, followed in frequency by Galveston, TX (30.4%), Panama City Beach, FL (26.6%), and Corpus Christi, TX (12.4%).

Approximately 69% ( $n = 367$ ) of respondents indicated that they had gone saltwater fishing in the past 12 months. Fishing experience averaged  $38 \pm 0.5$  years. More than half of respondents (55.4%) reported that they fish at least monthly. 72% ( $n = 269$ ) of fishing respondents fished from shore, bridge, or pier; 84% ( $n = 314$ ) of fishing respondents fished inshore from a boat; and 49% ( $n = 183$ ) of fishing respondents

fished offshore for at least one day in the last year.

### 3.2. Perceptions of coastal habitats and fisheries ecosystem services

Perceptions of the relative performance of marshes vs. mangroves for fisheries ecosystem services were significantly different across geographies (Fig. 3). First, perceptions differed significantly by state of residence (Fig. 3a,  $p < 0.001$ ). Florida residents perceived that mangroves were better for delivering fisheries ecosystem services in contrast to Texas residents who perceived that marshes were better for delivering these services. Perceptions were also significantly different across study site (Fig. 3b,  $p < 0.001$ ). Specifically, significant differences were observed between both Cedar Key / Homosassa, FL and Galveston, TX ( $p = 0.001$ ) and Panama City Beach, FL, and Galveston, TX ( $p = 0.001$ ). Residents of Galveston, TX perceived better marsh performance for delivering fisheries ecosystem services in comparison to both Cedar Key / Homosassa and Panama City Beach, FL residents.

Recreational fishing frequency and locations created significant divisions among respondent perceptions of mangrove vs. marsh support for coastal fisheries (Fig. 4). Frequency of recreational fishing divided perceptions significantly (Fig. 4a,  $p = 0.024$ ), where respondents who reported more frequent fishing activity generally perceived better mangrove performance for delivering fisheries ecosystem services. When fishermen were disaggregated by fishing location, significant differences emerged as well. Fishermen who fished from shore showed marsh preference for delivering fisheries ecosystem services in comparison to fishermen who did not fish from shore (Fig. 4b,  $p = 0.048$ ), while fishermen who fished offshore showed mangrove preference for delivering these services in comparison to fishermen who did not fish offshore (Fig. 4c,  $p = 0.001$ ). Fishermen who fished inshore and fishermen who did not fish inshore held similar perceptions (Fig. 4d,  $p = 0.266$ ).

In the ordinal logistic regression, respondent perceptions of coastal

habitats and their support of coastal fisheries were influenced by geography, shoreline condition and preference, recreational fishing activity, and demographic variables (Fig. 5). Significant predictor variables included study site, marsh shoreline condition, desired marsh shoreline condition, frequency of recreational fishing, and household income. Respondents from Galveston, TX and Corpus Christi, TX had significant mangrove preference in comparison to Cedar Key / Homosassa, FL respondents ( $p < 0.001$  and  $p = 0.0415$ , respectively) (Table S2). Perceptions were not significantly different for Cedar Key / Homosassa, FL and Panama City Beach, FL respondents. Residential-scale shoreline condition and preference both played a role in the significant divergence of perceptions for supporting coastal fisheries. Respondents with a marsh present on their shoreline rated the relative performance of mangroves higher for supporting coastal fisheries than respondents without a marsh on their shoreline ( $p = 0.046$ ) (Table S2). In contrast, respondents who expressed that their ideal shoreline would hypothetically include a marsh rated the relative performance of marshes higher for supporting coastal fisheries than respondents who did not desire a marsh on their shoreline ( $p = 0.020$ ) (Table S2).

Frequency of recreational fishing also emerged as an important predictor variable in the regression analysis (Fig. 5). Frequent recreational fishing conferred preference for mangrove habitats over marshes; respondents who fished weekly preferred mangroves for supporting coastal fisheries in comparison to respondents who never fish recreationally ( $p < 0.001$ ) (Table S2). Respondent perceptions for those with less frequent recreational fishing activity were not significantly different from perceptions of respondents who never fish recreationally. With respect to demographics, household income was the only variable that achieved significance in the model. Estimates among higher income levels were not significantly different from each other, but the lowest income level (less than \$25 k) differed significantly from multiple higher income categories (\$25,001 to 35 k,  $p = 0.0292$ ; \$75,001 to 100 k,  $p = 0.0209$ ; \$100,001 to \$150 k,  $p = 0.0412$ ; \$150,001 to \$250 k,  $p =$

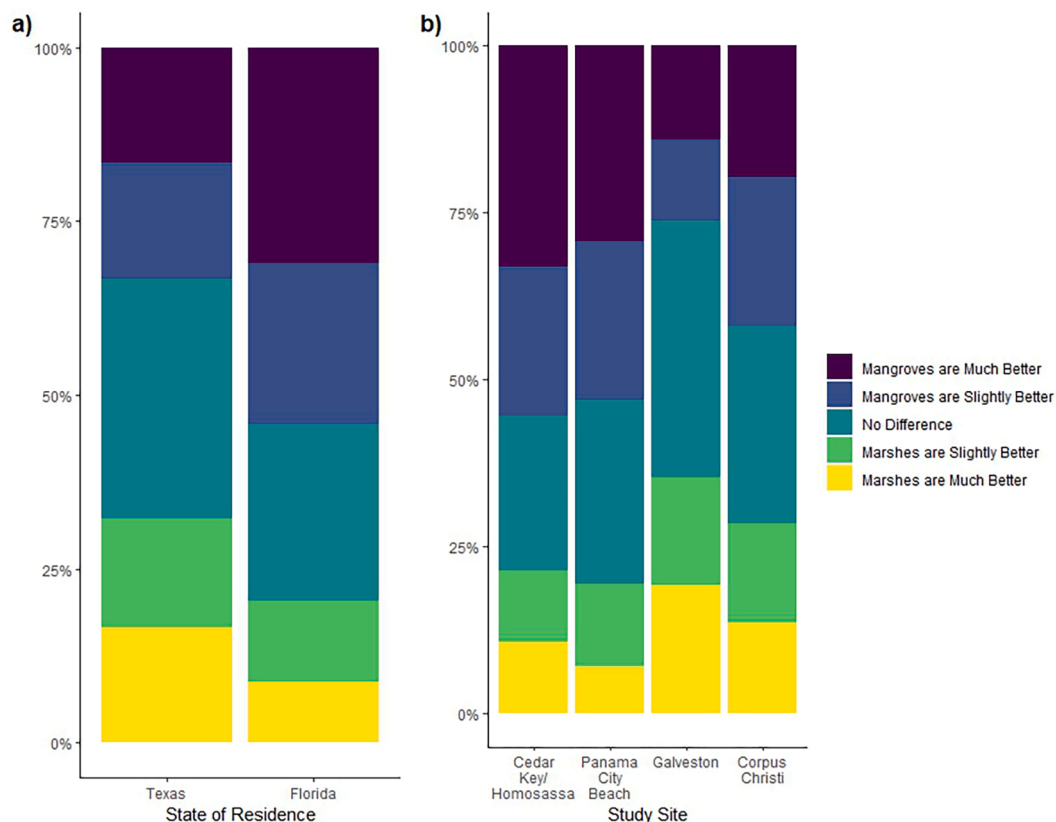


Fig. 3. Perceptions of the comparative ability of mangroves and marshes to support coastal fisheries across a) state of residence and b) study site.

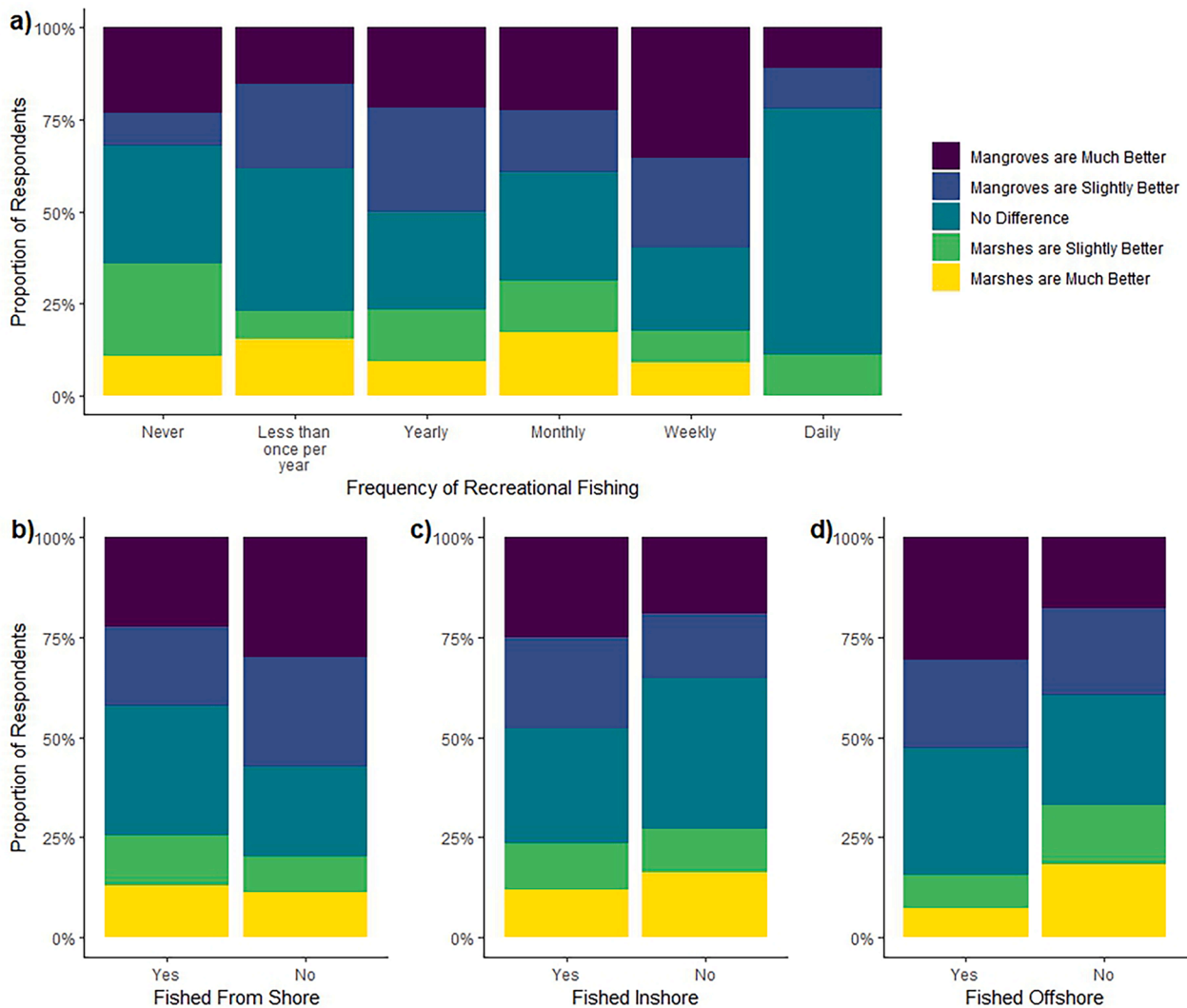


Fig. 4. Perceptions of the comparative ability of mangroves and marshes to support coastal fisheries across a) frequency of recreational fishing, and participation in the last 12 months in b) shore-based fishing, c) inshore fishing from a boat, and d) offshore fishing.

0.0387) (Table S2).

#### 4. Discussion

Geographic, environmental, social, and demographic factors influenced respondent perceptions of supporting ecosystem services delivered by marshes and mangroves. Both analytical techniques employed in our study revealed significant divergence in perceptions of mangrove vs. marsh for supporting fisheries based on geographic factors such as state and study site. The impact of geography in creating this divide is likely realized through the differing historical legacy and rate of change of mangroves across the study sites. On regional and local scales, winter temperatures have frequently exceeded thresholds that cause mangrove damage and mortality in the GoM (Osland et al., 2017a). This influence of extreme winter temperature is especially important across subtropical-temperate wetland transition zones in the Northern Hemisphere (i.e. China and the United States) (Osland et al., 2017b). Within the GoM region, differences in mangrove abundance and expansion rates across states are driven by distinct abiotic regimes in the east (i.e. Florida) and the west (i.e. Texas). The major abiotic regulator of mangrove presence and abundance in Florida and Louisiana is temperature minima, but Texas mangrove distribution is limited by interactions between temperature and precipitation, particularly in the southern part of the state (Osland et al., 2017b). Intense cold has resulted in frequent

local mangrove die-backs in Texas as recently as 2021 (Martinez et al., 2023; Kaalstad et al., 2024). In contrast, winter freeze events were last experienced in the 1980s in Cedar Key / Homosassa, FL and in 2010 in Panama City Beach, FL (Snyder et al., 2022). Given that survey respondents had an average waterfront residence time of twenty years (i.e. since 2000–2001), some of these residents have likely observed mangrove expansion, but to different extents depending on the freeze events experienced at each study site. The more continuous mangrove presence and more pervasive mangrove abundance in the state of Florida may be a driver of how residents in the state perceive mangroves more favorably for delivering fisheries ecosystem services in comparison to Texas residents.

Factors relating to shoreline condition and shoreline preference were significant in driving coastal habitat perceptions. The importance of resource access in driving perceptions has roots in geography, which suggests that perceptions are influenced by our proximity to natural features in space and time (Stedman, 2003; Brown and Raymond, 2007). Our assessment of respondents' biophysical environment as well as perceptions of their ideal environment provides nuance to this perspective. Shoreline condition (i.e. marsh presence/absence) and shoreline preference (i.e. desired marsh presence/absence on an ideal shoreline) were not significant under a bivariate comparison alone but became significant predictors in the full specified ordered logit model. Two main findings can be identified concerning these results. First, the

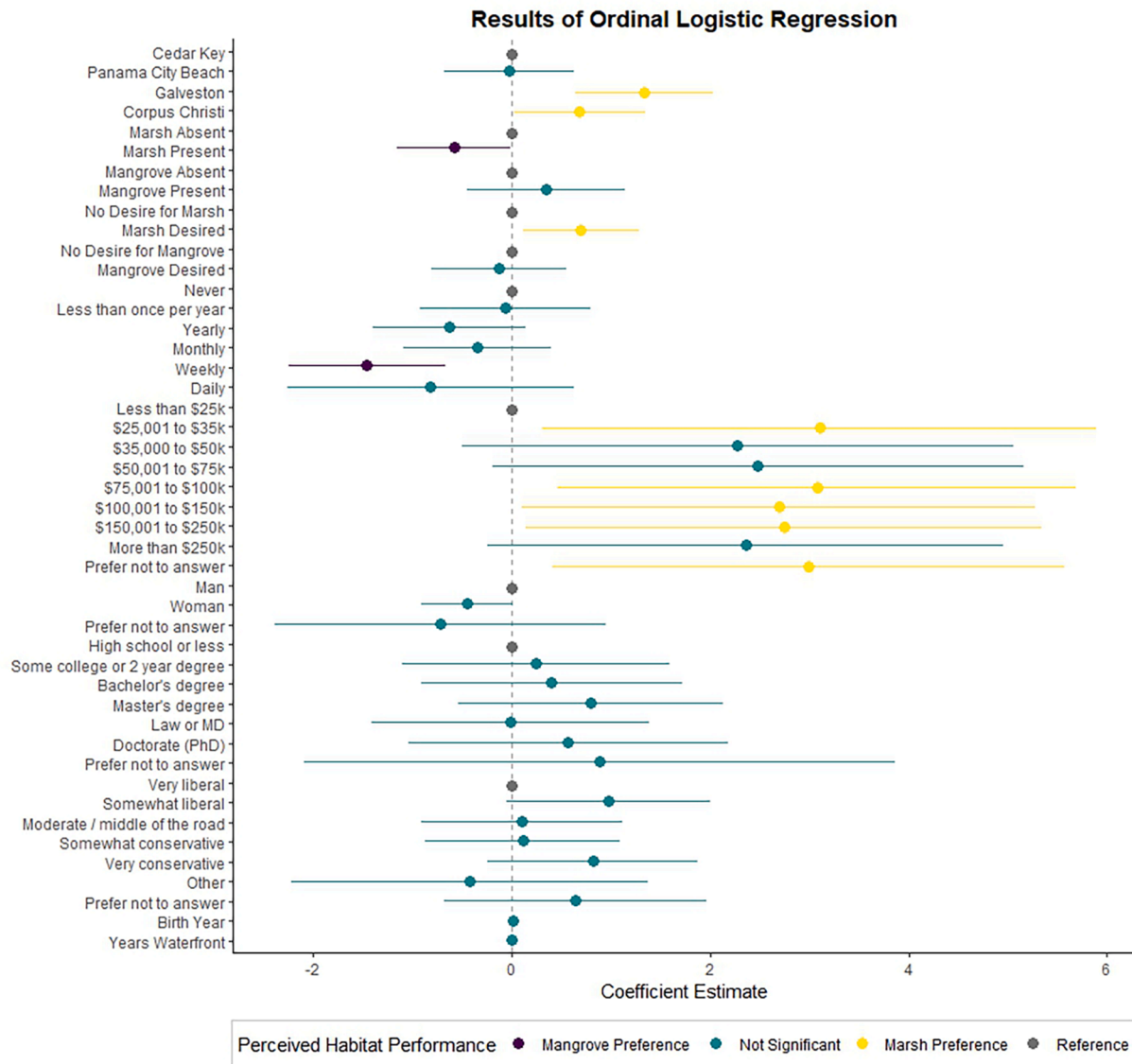


Fig. 5. Ordinal logistic regression results for the perceived relative performance of marshes and mangroves for fisheries ecosystem services. Dots represent generalized ordered logit estimates, and whiskers represent confidence intervals. Parameters that do not overlap with the dashed gray line are significantly different from the reference group for that variable. Positive estimates indicate increasing probability of marsh preference, and negative estimates indicate increasing probability of mangrove preference.

presence of marsh or mangrove on a respondent’s shoreline does not necessarily drive them to prefer one or the other of these habitats. In fact, respondents with marsh on their shoreline reported higher mangrove performance for delivering fisheries ecosystem services than respondents without marsh, and respondents rated these habitats similarly regardless of mangrove presence or absence on their shoreline. Second, a respondent’s actual shoreline condition does not necessarily represent the shoreline they most desire to have. This is evidenced by the contrasting perceptions of residents for marsh shoreline condition vs. attitudes. Specifically, respondents with marshes present on their shoreline prefer mangroves for supporting fisheries, but respondents who express marsh as a desired shoreline type prefer marshes for supporting fisheries. These findings highlight that the current state of a waterfront resident’s shoreline may not reflect their preference or perception of performance for that shoreline to deliver ecosystem services. In light of this, we argue that to understand shoreline change, it is critical to consider both the existing environmental (i.e. shoreline condition) and social perceptions (i.e. shoreline preference) of waterfront residents.

The use of fisheries resources by our waterfront resident sample was also influential in driving perceptions of mangroves and marshes for delivering fisheries ecosystem services. More frequent recreational fishing activity conferred significant mangrove preference under the bivariate comparison as well as in the regression analysis. In addition, the role of fishing location was demonstrated to create diverging perceptions of coastal habitats. Fishermen who fish from shore held marsh preference in comparison to other fishermen, but fishermen who fish offshore held mangrove preference in comparison to other fishermen. This suggests that fishing location impacts perceptions of fisheries ecosystem services, but more research could help to elucidate how fishing behavior in space and time interacts with perceptions of marshes and mangroves and their delivery of these services.

Demographic variables did not emerge as important predictors of perceptions of coastal habitats delivering fisheries ecosystem services. Respondents in multiple higher household income categories held marsh preference in comparison to the lowest income category, but perceptions among wealthier respondents largely overlapped. Other demographic predictors (i.e. birth year, gender, highest level of education, and

political affiliation) were not significant predictors of perceptions. This result illustrates the potential limited influence of these factors in the perceptions of our waterfront resident sample. While this is in contrast to much research in environmental psychology and sociology that has defined our understanding of how identity contributes to environmental perceptions and attitudes (Dunlap and Van Liere, 1978; Van Liere and Dunlap, 1980), waterfront residents are typically less demographically diverse than the broader coastal counties they reside within. The incorporation of demographic variables into the full ordered logit model revealed that these variables may be mediating factors that conceal the importance of residential-scale environmental conditions and attitudes to drive perceptions. However, it was necessary to remove the race/ethnicity variable as a predictor in the regression analysis for rigorous model specification. Overall, more respondents fell into majority groups (e.g. white, male, affluent, older) for all measured demographic variables in comparison to the coastal counties in which these respondents reside. This demographic homogeneity may implicate an equity issue in shoreline decision-making, and the role of demographics in perceptions of waterfront homeowners in comparison to coastal residents at large is an area for future exploration.

Our study contributes to building evidence that ecosystem service assessments can benefit from a social valuation technique where outcomes can be evaluated under the characteristics of the relevant beneficiaries of those services. Social and environmental determinants of environmental perceptions and behaviors have been increasingly demonstrated in the ecosystem services literature (Martín-López et al., 2012; Hicks and Cinner, 2014; Brown et al., 2020; Su and Gasparatos, 2023). Our study shows that perceptions of coastal habitats for delivering ecosystem services were driven not by demographics, but by the geographic context, environmental attitudes, and resource use of our respondents. This means that if residents' shoreline management decisions are presumed based on readily apparent characteristics such as shoreline condition and demographics, concealed factors such as shoreline preference and fishing behaviors may not receive adequate attention. This is especially critical as shifting habitats driven by climate change, such as mangrove expansion, may alter residents' interactions with their shoreline. If people's perceptions and values are not contextualized adequately by their lived experience, policies and programs designed to bring ecosystem services back to those people may not deliver (Menzel and Teng, 2010; Jax, 2010). Thus, investigating environmental and sociocultural predictors of ecosystem service perceptions in tandem can help to produce constituent-driven shoreline policy and management.

## 5. Conclusion

Climate-driven habitat shifts are transforming ecosystem structure and function globally with implications for communities reliant on ecosystem services. Social valuation of ecosystem services through constituent perceptions highlights demand and prioritization for these services. Among GoM waterfront property owners, geography, shoreline condition and preference, recreational fishing access, and household income were significant predictors of perceptions of mangrove vs. marsh relative capacity to support coastal fisheries. Specifically, respondents who lived in Florida, had a marsh shoreline condition, did not desire marsh on their property, engaged in frequent recreational fishing activity, and fell into the lowest income category perceived that mangroves were better for performing fisheries ecosystem services in comparison to their surveyed counterparts. Waterfront residents make decisions about their parcels that can scale up to determine the composition of entire shoreline areas. However, these relevant parties are susceptible to shifts in nearshore habitats and their associated ecosystem service delivery, which can reshape their perceptions of these habitats and their behaviors along shorelines. As places at the land-sea interface undergo rapid social-ecological change, it is important to establish a reference point of place-based perceptions of residents

regarding coastal habitats for their roles in ecosystem service delivery. In order to design informed and community-driven strategies for climate resilience, we must consider the social forces that act to shape our coastal ecosystems and societies.

## CRedit authorship contribution statement

**Savannah H. Swinea:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **A. Randall Hughes:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Michael J. Osland:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Christine C. Shepard:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Kalaina B. Thorne:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Jahson B. Alemu:** Writing – review & editing, Conceptualization. **Rémi Bardou:** Writing – review & editing, Conceptualization. **Steven B. Scyphers:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

## Data availability

Data available from the Gulf of Mexico Research Initiative Information & Data Cooperative (GRIIDC): <https://doi.org/10.7266/n8jvnr3>. Replication code: <https://github.com/shswinea/MangMarshFish>.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.landurbplan.2024.105203>.

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