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Informing the Development of the Coast Model of the Watershed Game

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Abstract: Since 2006 the Watershed Game, a role-playing simulation and serious game focused on managing nonpoint source pollution at the watershed scale, has been used across the U.S. to improve understanding of, commitment to, and involvement in watershed-scale management. Stakeholder or student participants manage a fictitious watershed to meet a "Clean Water Goal." Designed for freshwater watersheds, the game is available in local leader and classroom versions, and play is led by trained facilitators or educators. To inform the expansion of the Watershed Game to include coastal watersheds, a needs assessment was conducted to identify water quality and management challenges in coastal regions, using the Gulf of Mexico and South Atlantic as a case study. Several methods for assessing critical coastal management challenges and key land uses to prioritize in the game were employed: a review of reports, expert focus group, survey of Gulf and South Atlantic regional experts, second survey of coastal experts from the National Sea Grant Network to verify widespread applicability, and finally pilot tests of the draft game. Results showed high agreement among assessment methodologies regarding the most critical coastal challenges and important land uses to feature in the game. As a result, the Coast Model of the Watershed Game focuses on three primary nonpoint source pollutants, excess nitrogen, excess phosphorus, and excess sediment. Additionally, results indicated a need to integrate a new game element, resilience to flooding, which has been added to the challenge of winning the game by meeting the Clean Water Goal.

Keywords: *watershed management, nonpoint source pollution, flooding, community resilience, Watershed Game, serious games, stakeholder engagement, extension*

Water resource challenges are increasing in severity and frequency, resulting in negative ecological, social, and economic impacts to communities. This is particularly true for the impacts of nonpoint source pollution, despite efforts to mitigate it in the United States (e.g., Stets et al. 2020). Nonpoint source pollution cannot be managed effectively on a community-by-community basis. Rather, management must occur on a watershed scale. This can be problematic, given that land and water management traditionally have been based on jurisdictional boundaries, whereas watersheds cross multiple political and jurisdictional boundaries (Uitto and Duda 2002). In transitioning to watershed-level management, managers often struggle to balance the competing and sometimes divisive interests, cultures, and perspectives of stakeholder groups while seeking to sustain and improve the health of water resources at a watershed scale (Medema et al. 2016). These challenges are compounded in coastal regions. Relative to other areas, coastal watersheds are among the most densely populated, biologically rich, and economically important. They are also highly vulnerable to water-related threats (Gray 1997; Lotze et al. 2006). Transitioning from managing within political boundaries to managing watershed-wide requires managers to employ methods that increase the understanding,

Research Implications

- The complexity and interrelated nature of issues affecting coastal watersheds from both upstream environments and coastal waters, make the intensive approach to information gathering prior to game development described in this paper worthwhile.
- Though water quality challenges vary in relative importance in different coastal regions, experts throughout the coastal United States consistently rated excess nitrogen, phosphorus, and sediment as critical nonpoint source water pollutants.
- Watershed management issues and the associated land uses are similar throughout the U.S. coastline, making it possible to create a generic coastal watershed game that can be used across coastal regions, including the freshwater systems of the Great Lakes.
- This paper demonstrates the value of querying local experts and the literature prior to designing content, elements of play, critical challenges, and game goals to ensure that serious games help consolidate learning around the issues that are most influenced by stakeholders and depend on collaboration.

investment, engagement, and collaboration of a wide range of stakeholders, many of whom are new to or resistant to such changes.

The successful engagement of stakeholders can be supported through interactive methods of teaching and learning. These methods, often called experiential learning, can be traced back as far as John Dewey (1938) and have been supported as an effective means to educate audiences since the 1950s (Rusca et al. 2012). Gaming and simulations as forms of experiential learning are documented in the extension literature as early as 1978 (Boehlje and Eidman). Though many terms (e.g., gaming models, games, role-play simulations, or science-based role-play simulation exercises) have been used to refer to games designed to engage adults in learning or collaboration (Rumore et al. 2016), "serious games," which are played for reasons beyond entertainment (Bathke et al. 2019), have a strong track record of being used to help engage people in discussions about difficult challenges (Rumore et al. 2016), stimulating collaborative learning and knowledge sharing, spawning negotiation and joint decision-making, and building trust, despite sometimes conflicting interests (e.g., Uitto and Duda 2002; Reckien and Eisenack 2013). These games appeal to adult and professional audiences, while the basic tenets of games as fun and engaging experiential tools remain one of the benefits to their use in extension (Boehlje and Eidman 1978; Rumore et al. 2016). Specifically, games, simulations, and in particular, serious games, are useful for encouraging social learning around issues such as transboundary water management (e.g., Van Bilsen et al. 2010; Hoekstra 2012). Serious games may be particularly helpful when addressing difficult and potentially divisive environmental issues, as games can promote dialogue, civility, and mutual respect. In this context, small-group simulations encourage teamwork, cooperation, and enhanced understanding of management challenges and solutions, while building collaboration skills across various stakeholder groups (Bathke et al. 2019).

The Watershed Game, a nonpoint source water pollution educational program and serious game, was designed with the specific intent of breaking down barriers among diverse stakeholder groups involved in watershed management. The game increases understanding of how human alterations to land within a watershed impact downstream water quality, while introducing tools and practices that are commonly used to prevent or ameliorate those impacts. The Watershed Game was developed for freshwater environments by Minnesota Sea Grant, University of Wisconsin Extension, and the Lake Superior Research Institute. Minnesota Sea Grant and the University of Minnesota Extension enhanced and expanded the concept 15 years ago, and the Watershed Game and its supporting program have now expanded to 22 states. Early designs focused on inland waters impacted by excess phosphorus and sediment. In 2018, the authors initiated a case study to inform the development of a Coast Model of the Watershed Game, as described in this paper.

The Watershed Game is a face-to-face, serious game that involves teams of participants in a simulation of real-life challenges faced by local communities and land and water owners/managers when addressing water quality at an individual land use and watershed scale. Designed to allow participants to "see" representative aspects of their communities, lives, and livelihoods in the game board and through gameplay, the game allows players to learn about and test actual management and policy tools with authentic, yet fictitious management challenges. The game offers an opportunity for dialogue among and across teams, uses repetition to deepen learning and understanding, and requires collaboration across teams for ultimate success—to "win" the game. A facilitator actively manages the interaction and relates the experiences to local challenges during the game and during a post-play discussion.

These characteristics of the Watershed Game embrace many of the documented benefits of games. It offers a fun and enjoyable activity that entices individuals to engage with a larger group (Falk et al. 2001; Burby 2003; Bathke et al. 2019). It allows for a controlled and safe environment from which to learn about and test complex concepts (Mayer 2009; Rusca et al. 2012; Rumore et al. 2016; Bathke et al. 2019) that are directly relatable to specific challenges being faced in participants' communities and watersheds (Peters and Vissers 2004; Arndt and LaDue 2008; Rumore et al. 2016; Bathke et al. 2019). Participants see the challenges their communities face within the context of the whole watershed, and visualize the positive, collective changes that result from collaboration with other watershed stakeholders and communities as they work to improve water quality by applying solutions on the land. The visual elements and hands-on actions of the game allow participants to connect to their sense of and attachment to place. This, in turn, triggers emotional bonds and personal meaning to the lessons learned (Hidalgo and Hernanez 2001; Brehm et al. 2004; Nanzer 2004; Thompson and Prokopy 2016). The act of role-playing and the repetitive rounds allow participants to experience and test different actions and observe the ensuing results (Oblinger 2004). Repetition also allows individuals to see how actions build over time and across land uses for the good of the whole (Rusca et al. 2012).

Description of the Watershed Game

Prior to the development of the Coast Model, the primary focus of the Watershed Game was nonpoint source pollution (see Table 1 for descriptions of key components of the Watershed Game). Game facilitators had the option to play with either of two critical freshwater pollutants: phosphorus as the key excess nutrient; or sediment, one of the most common causes of pollution in rivers and streams (U.S. EPA 2017). The goal of the game was, and continues to be, to use limited financial resources to reduce excess sediment and/or excess phosphorus to levels that meet a "Clean Water Goal," even as participants encounter "Unanticipated Events" such as severe storms that can cause setbacks in teams' progress in pollution reduction. Participants work in land use teams around a large, stylized watershed map (the "Watershed Game Board"). The gameboard is organized into land use areas, which include graphical elements representing water quality impacts. As participants play, they experience how each land use impacts water quality, increase their knowledge of best management practices (BMPs) represented on "Tool Cards," and learn how specific choices can reduce adverse impacts. "Unanticipated Events" introduced during play provide additional teaching opportunities and allow the facilitator to control funds available to land use teams. Limited funds force participants to work collaboratively across land use teams in the final round if they are to meet the Clean Water Goal and collectively win the game. In so doing, participants experience the necessity and benefits of considering, involving, and cooperating across land uses within the watershed, illustrating that collaboration at a watershed scale is an essential part of effectively managing water and land use.

The learning objectives of the watershed game are to:

- Understand that all land uses within a watershed contribute pollutants and impact water quality.
- Identify specific sources of pollutants from each land use.
- Apply best management practices (plans, practices, and policies) to prevent or reduce impacts.
- Choose solutions based on available funds, benefits, and feasibility.
- Understand that solutions that benefit the whole watershed require collaboration across jurisdictions and land uses.

The Watershed Game is available as a Local Leader Version for use with elected and appointed officials, community leaders, watershed organizations, and other adult audiences who have a role in water resource management. In addition to the new Coast Model, the Local Leader Version is available in three models: headwater stream, lake, and large river, which can be linked together to represent an entire watershed basin. The Classroom Version is a modification of the headwater stream (known as the "Stream Model") of the Local Leader Version, adapted for use with middle to high school students in formal and nonformal learning settings.

Need for a Coast Model of the Watershed Game

Over the 15 years of its use across much of the United States, water resource professionals and educators have recognized the value of the Watershed Game as an extension, education, and engagement tool. As game use expanded beyond the Great Lakes Region, multiple requests were made to add excess nitrogen to excess phosphorus as a second nutrient of concern, while retaining excess sediment as a critical water quality nonpoint source pollutant. Additionally, requests from several coastal regions were made for coastal models in both the Local Leader and Classroom versions, and for a stronger emphasis on planning in the face of climate change (Bilotta and Hagley 2017; Minnesota Sea Grant 2019). Strong interest expressed at game facilitator training workshops in the southeastern United States provided an opportunity for a case study to frame the development of a new coastal model. Coast Model game development was initiated in 2018 with the formation of the project development team. The goal was to identify critical environmental challenges impacting U.S. coastal watersheds (including the Great Lakes) that could be addressed within the existing structure of the Watershed Game.

The Coast Model of the Watershed Game adds a missing element to an existing set of game models, allowing the combined models of the Watershed Game to encompass the entirety of a watershed from its headwaters to its coastal outlet. To ensure consistency with previous models of the game, the team approached the needs assessment with

Table 1. Key components of the Watershed Game.

Component	Description
Watershed Game Board	The game board is a fictional landscape showing typical land uses that include graphical elements to represent key potential sources of pollution to different waterbodies.
Clean Water Goal	The goal of the game is to reduce nonpoint source pollution to levels that protect human health and aquatic ecosystems. This is achieved by selecting and implementing tools to meet a Clean Water Goal and is modelled after the Federal Clean Water Act Total Maximum Daily Load (TMDL) program.
Tool Cards	Tool Cards represent policies, plans, and practices (often referred to as best management practices) that prevent or reduce nonpoint source pollution. Each land use has a set of Tool Cards, and each Tool Card fits in a specific location on the game board to show what implementation might look like.
Plan Cards	Plan Cards can be purchased by individual land use teams and are used in the game to introduce the concept of planning and its benefits and costs. Plan Cards are introduced with minimal background, and land use teams decide if they want to invest a portion of their limited funds in a plan. The benefits are only realized if teams can articulate how their plan benefits their efforts to meet the Clean Water Goal.
Unanticipated Event Cards	Unanticipated Events include unplanned natural or human-caused events that can impact progress toward the Clean Water Goal. Examples include floods or other natural disasters as well as negligence or mismanagement that result in resources being diverted to address a different, urgent issue. During the game, Unanticipated Events are used as needed by facilitators to affect one or more land use teams by removing or rewarding funds or change the upstream pollutant load or Clean Water Goal.

two constraints: 1) existing game components (see Table 1) would be retained in the Coast Model; and 2) water quality parameters previously included would remain (i.e., excess sediment and phosphorus) to ensure the ability to cascade impacts across an entire watershed basin.

The needs assessment described in this paper explored what, if any, new water quality parameter(s) could be included to increase the game's relevance in coastal waters, without greatly lengthening the time required to play. Environmental challenges in coastal regions are complex and vast. As such, the needs assessment was also designed to broadly identify additional challenges, beyond water quality, that could be integrated, while recognizing the need to focus on challenges that are relevant to all U.S. coasts (including the Great Lakes). This assessment was designed to gather general information on the topic to inform game development and was not designed for statistical inferences. Results were interpreted with the intent of guiding the selection of additional parameters to include in the Coast Model, either as Unanticipated Events, sources of pollution, challenges to be addressed with Tool Cards, or in other ways to support learning and generate discussions with participants.

Methods

The project development team used five methodologies (the first four of which are described in detail in this paper) to gather and consolidate knowledge, research, and expert opinions to guide game development regarding critical coastal challenges and key land uses for addressing coastal land and water issues. Table 2 outlines the methods used, timing, and geographic focus of each method. The results of the fifth methodology, pilot workshops, will be summarized in a future publication.

Review of Reports

In fall 2018, 30 coastal reports, studies, and documents were reviewed to gain a foundational understanding of priority coastal issues, including water quality parameters most detrimental to U.S. coasts. Salient documents were identified through online research and recommendations from coastal professionals and practitioners. The initial internet search for reports focused primarily on the Gulf of Mexico and South Atlantic and used a variety of impact-related keywords (e.g., coastal stressors, coastal drivers, coastal impacts, coastal zone), along with state names (i.e., Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, and South Carolina). Sources were selected according to their potential relevance and usefulness in shaping the future focus of the tool, and included national, regional, and state reports. Examples of reports reviewed include National Estuarine Research Reserve Management Plans, State Coastal Management Program Section 309 Assessment and Strategies, the Gulf of Mexico Alliance

Table 2. Overview of methods used to inform the development of the Coast Model of the Watershed Game.

Approach	Method	When	Geographic Focus
Review of Reports	Review of reports with regard to coastal issues	Fall 2018	Predominantly the Gulf of Mexico and South Atlantic (with two National reports)
Focus Group	Regional experts convened online via an interactive virtual platform	December 5, 2018	Gulf of Mexico and South Atlantic
Online Regional Survey	Respondents sought through relevant known contacts, listservs, conferences, etc.	October 31-December 3, 2018	Gulf of Mexico and South Atlantic
Online Sea Grant Survey	Respondents sought through National Sea Grant Network	March 19-April 9, 2019	Coastal regions nationwide, including the Great Lakes
Pilot Workshops*	Trial gameplay and focus group discussions	February 18 and 19, 2020	Gulf of Mexico and South Atlantic

*Will be summarized in subsequent publication.

Governors' Action Plan III, and local watershed management plans (see Appendix A for a list of reports). Key information from each report was summarized, grouped, and coded to generate a broad understanding of regional priorities.

Focus Group

In December 2018, the project team conducted a two-hour, virtual focus group with coastal professionals from the Gulf of Mexico Region. Participants, selected from Sea Grant and other coastal management and education networks, were identified based on expertise in coastal environmental challenges. Twelve individuals participated (24 invited), representing four coastal states (Florida, 3; Alabama and/or Mississippi, 4; and Louisiana, 5) and a variety of backgrounds, including academia, nonprofit organizations, and federal, state, and local government. Participants were provided a short presentation on the Watershed Game and an overview of the preliminary investigations before participating in a facilitated group discussion. Questions focused on whether preliminary survey results resonated with participant understanding of key coastal challenges, the primary impacts associated with those challenges, and the most significant land uses impacting water quality in their area. Two team members took comprehensive notes during the discussion. These notes were transcribed, reviewed, grouped by theme (coastal issues, potential unanticipated event cards, potential tool cards, game development items, and items for further research), and scored by frequency.

Gulf of Mexico and South Atlantic Survey and National Sea Grant Network Survey

Qualtrics-based surveys were administered to coastal professionals in the Gulf of Mexico and South Atlantic Regions in fall-winter 2018 and then to the National Sea Grant Network in spring 2019 (see Appendix B for survey instruments). Surveys had the dual objectives of identifying critical water-related environmental challenges and primary land uses contributing to those challenges in estuaries and coastal areas. The Gulf of Mexico and South Atlantic (Regional) survey was pilot tested among the project development team and by two other survey experts within Sea Grant.

The Regional survey was distributed via email to colleagues with expertise in coastal research, education, or management in the region. Recipients were encouraged to share the survey with regional colleagues. In addition, the survey link was distributed broadly at the Bays and Bayous Symposium in Mobile, Alabama, November 28-29, 2018. The survey was open from October 31, 2018 through December 3, 2018.

The National Sea Grant Network (Sea Grant) survey was distributed to approximately 50 Sea Grant professionals (e.g., researchers, outreach professionals, educators, communications specialists) who represented the breadth of coastal issues across all U.S. coastal areas (including the Great Lakes). Recipients were encouraged to share the survey with other Sea Grant colleagues. The survey was open from March 19, 2019 through April 9, 2019.

The Sea Grant survey was nearly identical to the Regional survey and served to verify that findings from the Regional survey were relevant to all U.S. coastal areas (including the Great Lakes). It also served to identify opportunities for game expansions or modifications that might increase the relevance of the Watershed Game beyond the Gulf of Mexico and South Atlantic.

Pilot Workshops

In February 2020, pilot workshops were held in New Orleans, Louisiana and Mobile, Alabama to play the game and to gather input that informed refinement of the game components and the process of game play. Forty-one participants provided critical feedback. Detailed results of the pilot workshops will be summarized in a future publication.

Results

Review of Reports

Of the 30 reports reviewed, two were National in scope and three focused on the Gulf of Mexico. The remainder were state-specific, with a subset focusing on individual sites within states. States included Georgia (five reports); South Carolina, Florida, Alabama, and Louisiana (four reports each); Mississippi (three reports); and Texas (one report). Most reports identified multiple coastal challenges as priority issues. In total, the reports identified 25 priority issues (see Figure 1).

Five topics were identified in at least 10 of 30 reports, including land use change and development (60%), water quality degradation (43%), sea level rise (43%), impact of storms (43%), and flooding (33%). An additional three topics, including stormwater management-runoff, the influence of climate change, and erosion, were identified in nine reports (30%).

This review did not represent a comprehensive or quantitative analysis of all coastal impact assessments and reports, nor were all impacts independent of one another. Instead, the review served as an initial guide and baseline of information about potential coastal issues for consideration in the subsequent focus group and surveys, and for possible inclusion in the new Coast Model. Results showed coherence among reports regarding issues that negatively affect water quality (e.g., water quality degradation, erosion, sediments, hypoxia, nutrients), and modifications that contribute to and impacts associated with flooding (e.g., land use change and development, sea level rise, impact of storms, flooding, stormwater management).

Focus Group

The collective views of participants shared in the focus group discussion yielded rich data that were grouped into themes. Excess nutrients in water was the most discussed coastal issue, followed by flooding, climate change and sea level rise, coastal erosion, marine debris, and water pollution. There was general agreement that excess nutrients, flooding, climate change/sea level rise, and coastal erosion were common problems across multiple states in the region. Some topics raised were highly localized, state-specific issues (e.g., phosphate mining in Florida), rather than high priorities across the region. There was recognition that to ensure applicability of the Coast Models of the Watershed Game to coastal professionals across the U.S. (including the Great Lakes), the highly localized topics should not be considered as a primary focus of the game. More locally-specific challenges were retained as possible Unanticipated Events or other game elements that could be used where and when appropriate.

Gulf of Mexico and South Atlantic Survey and National Sea Grant Network Survey

The 117 respondents of the Regional survey represented a wide variety of affiliations and professional roles, although the survey did not collect respondents' specific locations within the region. The 30 respondents of the Sea Grant survey represented each of the five coastal regions of the U.S., including the Great Lakes (12), Gulf of Mexico (7), Southeast (5), Northeast (3), and Pacific (3). While a larger response rate would

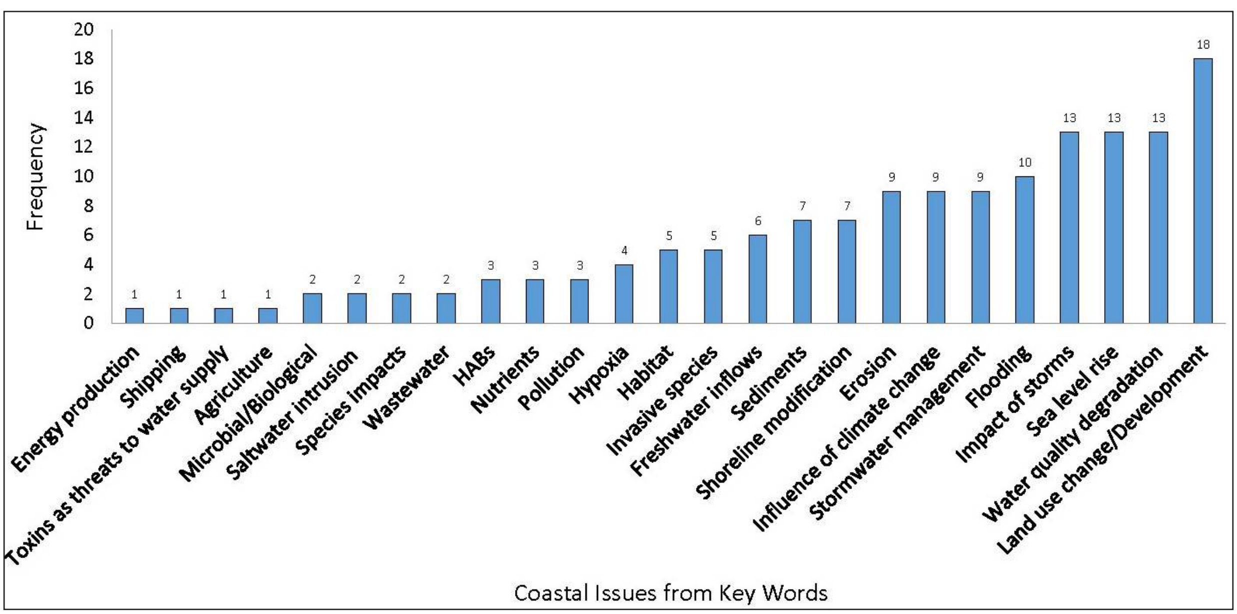

Figure 1. Coastal issues identified in the review of reports.

have been preferred, it is worth noting that results reflect input and representation from professionals from each of the U.S. coastal regions.

Coastal Challenges. The surveys provided a list of 14 specific coastal challenges, generated in part by results of the review of reports. Participants were asked to mark all issues they considered to be challenges impacting their coastal lands and waters. Table 3 compares the percent of respondents in each survey that selected each challenge (respondents could choose as many as desired, and on average chose 7-8 each). Erosion, flooding, nutrients, and harmful algal blooms (HABs) stood out as the top four most often-selected challenges in both the Regional and Sea Grant surveys. Each challenge was identified by a minimum of 67% of respondents from each survey. Excess nitrogen (55% Regional and 57% Sea Grant) and fecal coliform (47% Regional and 50% Sea Grant) were close behind and in close agreement across the two surveys. Coastal land loss was selected as a challenge by 68% of Regional survey respondents and by 60% of Sea Grant survey respondents. Resilience, excess phosphorus, and excess sediment were chosen as challenges by a markedly higher percentage in the Sea Grant survey than in the Regional survey, whereas saltwater intrusion was markedly more important in the Regional survey.

Top Three Critical Coastal Challenges. Respondents were asked to consider the list of challenges they identified in the previous question and choose three they considered most critical in terms of potential impacts to the natural and socioeconomic environments along the coast in their area. Figure 2 shows the percent of respondents who selected any of the most often identified challenges as one of the top three critical challenges impacting their coast. The percentage of respondents selecting each challenge as one of the top three challenges in their area ranged from 2% (excess flow) to 58% (coastal land loss) in the

Table 3. Challenges and critical challenges impacting coastal lands and waters identified by respondents to the Regional survey and Sea Grant survey.

Coastal Challenges	Regional Survey (117 Respondents)		Sea Grant Survey (30 Respondents)	
	Identified as a coastal challenge	Identified as one of the "top three critical challenges"	Identified as a coastal challenge	Identified as one of the "top three critical challenges"
Erosion	**71%**	23%	**73%**	30%
Flooding	**68%**	34%	**73%**	52%
Coastal land loss	**68%**	58%	**60%**	29%
Nutrients	**67%**	38%	**87%**	32%
Harmful Algal Blooms (HABs)	**66%**	30%	**87%**	30%
Saltwater intrusion	**61%**	23%	33%	6%
Excess nitrogen	**55%**	21%	**57%**	6%
Fecal coliform	47%	15%	50%	10%
Resilience	43%	n/a	**67%**	32%
Pathogens	40%	10%	40%	13%
Excess phosphorus	38%	7%	**57%**	13%
Elevated water temperatures	35%	11%	27%	10%
Excess sediment	30%	11%	**60%**	(16%)
Excess flow	8%	2%	20%	(3%)

Note: Bolded items were selected by more than 50% of respondents in each survey.

Regional survey and from 3% (excess flow) to 52% (flooding) in the Sea Grant survey.

As Figure 2 demonstrates, coastal land loss, flooding, nutrients, HABs, and erosion rose to the top in both surveys as critical challenges. However, there were notable differences between survey groups. Though coastal land loss was considered to be a coastal challenge by a high percentage of respondents in both surveys (see Table 3), it was considered a critical challenge by more respondents in the Regional survey (58%) than in the Sea Grant survey (29%). This is not a surprising result, particularly given that 39% of Sea Grant survey respondents were from the Great Lakes Region where coastal land loss is relatively limited and driven by periodically-high water levels and major storm events rather than by the rising sea levels and other factors causing land loss in the low-lying Gulf of Mexico. In contrast, Sea Grant respondents chose flooding as a top critical challenge at a higher percentage than Regional respondents (52% versus 34%, respectively).

Resilience was chosen as a coastal challenge by 67% of respondents and as one of the top

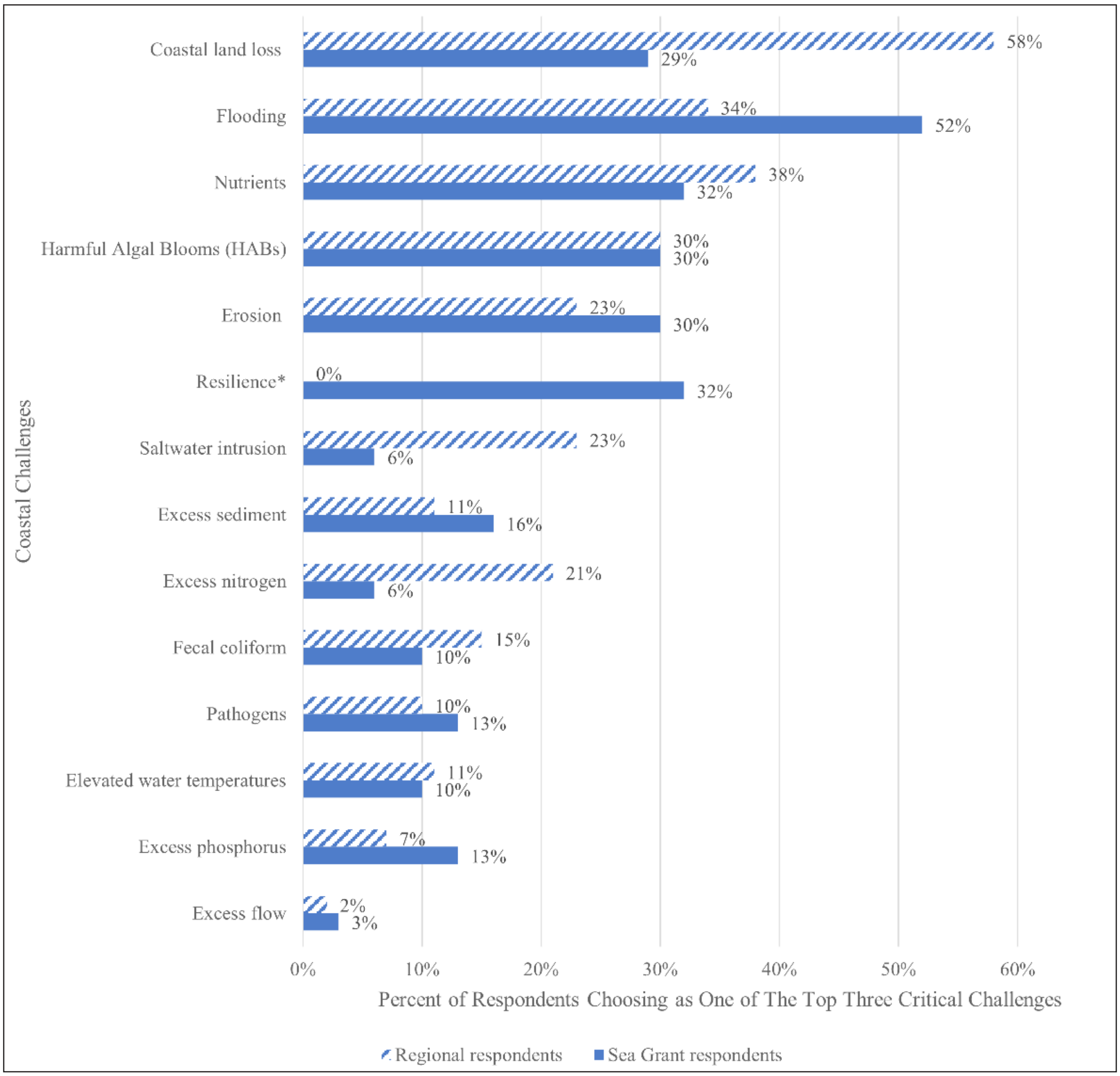

Figure 2. Percent of respondents choosing each item as one of three critical challenges in Regional and Sea Grant surveys. *Note: Resilience was inadvertently omitted from the Regional survey as a choice for the top three critical challenges.

three critical challenges by 32% of respondents in the Sea Grant survey. In the Regional survey, 43% selected resilience as a coastal challenge. Resilience was inadvertently omitted from the Regional survey as one of the choices for the top three critical challenges, but the high level of interest evident in the Sea Grant survey as well as the importance of increasing coastal resilience to flooding along all coasts suggested it was worthy of further consideration in game design.

Though excess nutrients were considered a top critical challenge in both surveys, there were clear differences in the two surveys in terms of which nutrient was of most concern to survey respondents. A higher percentage of Regional survey respondents than Sea Grant respondents ranked nitrogen as a top challenge (21% and 6%, respectively) whereas the reverse was true for excess phosphorus (7% and 13%, respectively).

It is important to note that recognition by survey respondents that something is a challenge to their coasts did not necessarily equate with the degree of agreement that it is a critical challenge in terms of overall potential impacts to the natural and socioeconomic environments along their coasts. For example, erosion was chosen as a coastal challenge by 71% of Regional respondents (the highest percent of the 14 options), yet it was identified as one of the critical challenges by only 23% of the same group (see Table 3, column 2).

Identification of Land Uses Contributing to the Top Ranked Critical Coastal Challenges. Respondents were asked to consider the top three critical challenges they identified and then select the primary land uses from a list (Appendix B: Survey Instrument Q5,6,7) that contribute to those challenges. Table 4 reports the top five land uses associated with the top three critical challenges identified, except where the fifth and sixth land uses were tied.

Excess nutrients and HABs are closely related challenges. Land uses identified by respondents as contributing most to both were urban and residential, including wastewater (56% of Regional survey respondents and 88% of Sea Grant survey respondents) and agriculture (73% Regional and 89% Sea Grant). Heavy industry was considered to be a contributor to excess nutrients by 43% (Regional) and 40% (Sea Grant), and to HABs by 37% (Regional) and 11% (Sea Grant) of respondents. Other land uses seen as contributing to nutrients and HABs, though to a lesser extent, included forestry and silviculture, ports and harbors, and recreation and tourism.

Flooding was considered to be most affected by urban and residential land use (58% of Regional respondents and 50% of Sea Grant respondents). Agriculture and heavy industry were considered to be major contributors to flooding by a smaller percentage of Regional survey respondents (15% each) than in the Sea Grant survey (31% for agriculture and 38% for heavy industry). Similarly, ports and harbors were considered important influences on flooding by fewer respondents in the Regional survey (10%) than the Sea Grant survey (25%). Flood control, though not a "land use" as defined in the Watershed Game, was considered important to the challenge of flooding in both surveys (50% Regional and 56% Sea Grant).

Pilot Workshops

In February 2020, pilot workshops were held in New Orleans, Louisiana and Mobile, Alabama, to play the draft Coast Model of the game and gather input to inform refinement of the game components and the process of game play. Forty-one participants provided feedback. As a result of the feedback received from workshop participants, the Coast Model of the Watershed Game includes two major scoring components. Like the original Watershed Game, participants work in land use teams and finally as a collaborative watershed group to reach a Clean Water Goal. Simultaneously, each Tool Card also describes and scores the Tool Card plans, practices, or policies in the context of how they will influence community resilience to flooding. Unanticipated Events place more emphasis on extreme flooding and nonpoint source, HAB-related events. Workshop participants indicated that these modifications provided a more comprehensive, realistic simulation of the challenges encountered in managing watersheds in coastal regions.

Discussion

The combined results from the literature review, focus group, and surveys constituted a needs assessment to inform the development of the new Coast Model of the Watershed Game. They were not designed for statistical inferences. This case study shows how these methods ensured that the Coast Model will resonate across all U.S. coasts, offers flexibility to address educational needs in any region, and can be coupled with the other game models to encompass the entirety of a large, multi-faceted watershed basin from its headwaters to its coastal outlet. Expanding the Watershed Game's geographic scope to include coastal watersheds provided an opportunity to evaluate the importance of additional nonpoint source pollutants, particularly nitrogen, and to integrate other coastal challenges. Based on the results of this assessment, the development team prioritized the issues of nutrients, flooding, and HABs as critical coastal issues for consideration in the Coast Model, along with resilience.

Pollutants

The importance of phosphorus or nitrogen as the limiting nutrient varies widely in different geographical regions and in freshwater versus oceanic systems. Factors such as upstream soils, land uses, nutrient sources, and nutrient loads impact the relative importance of nitrogen versus phosphorus in triggering excess algal blooms, HABs, and subsequent water quality degradation (Oelsner and Stets 2019). Similarly, the role of sediment varies widely across coastal regions of the U.S. Some areas are confronted by excess sediment, while others are challenged by a loss of sediment inputs. For example, the latter is particularly true in the Mississippi River Delta, where flood control, river rerouting, erosion, and channelization have resulted in a lack of sediment, causing significant land loss. Finding a way to encompass these variabilities and link all three (nitrogen, phosphorus, and sediment)

Table 4. Primary land uses contributing to the critical challenges from the surveys.

	Regional Survey (117 Respondents)			**Sea Grant Survey (31 Respondents)**		
Top land uses identified as contributors to top challenges identified in the surveys	**Respondents identifying this as a land use contributing to nutrients**	**Respondents identifying this as a land use contributing to flooding**	**Respondents identifying this as a land use contributing to HABs**	**Respondents identifying this as a land use contributing to nutrients**	**Respondents identifying this as a land use contributing to flooding**	**Respondents identifying this as a land use contributing to HABs**
Urban and residential, including wastewater	82%*	58%*	86%*	80%*	50%*	56%*
Agriculture	73%*	15%*	86%*	80%*	31%	89%*
Heavy industry	43%*	15%*	37%*	40%*	38%*	11%
Forestry/ silviculture	20%		20%			22%*
Ports and harbors	18%	10%		20%	25%	11%
Recreation and tourism	18%		17%	30%		11%
Flood control		50%*		20%	56%*	
Oil and gas exploration and extraction		10%				

*Starred items were the top three primary land uses contributing to the identified critical coastal challenges in each survey.

pollution challenges across a watershed basin was paramount.

One of the most important design parameters behind the Watershed Game is flexibility. The inclusion of all three pollutant options furthers that flexibility and maximizes the educational potential of the game by allowing facilitators to select the pollutant most important to manage in order to improve water quality in their region. For example, a game facilitator in the Mississippi Delta Region would most likely choose nitrogen rather than excess sediment as their pollutant of concern when leading the game; however, they could incorporate discussion about coastal land loss and reduced sediment loads in the context of increases in severity of coastal flooding as discussed in the "Flooding and Resilience" section below.

Harmful algal blooms (HABs) were noted as a significant coastal challenge and are associated with excess nutrients, specifically nitrogen and phosphorus (Anderson et al. 2002). Thus, the project development team determined that HABs are an outcome of excess nutrients and could be addressed explicitly in the game as an Unanticipated Event. This allows the game facilitator the opportunity to draw particular attention to this challenge and its health risks and make connections to how land uses in specific geographic areas contribute to their occurrence.

Land Uses

Results guided the development team's selection of the five land uses included on the Coast Model gameboard: industry and ports, agriculture, urban, residential, and rural coast. Primary land uses identified by respondents from both surveys as heavy contributors to nutrient impacts, HABs, and flooding include urban, residential, agriculture, and to a lesser extent, heavy industry. Recreation and tourism, forestry and silviculture, and ports and harbors were also considered to be contributors to nutrient impacts and flooding by a smaller percentage but are common land uses in most coastal environments. Practical considerations of game design limited the team to five land uses (see Figure 3), so land uses were consolidated, incorporating other traditional coastal uses less highly rated in the results, when possible. For example: Industrial Port combines heavy industry with ports and harbors, and integrates environmental justice issues by including a small, shoreside subsistence community dependent on fishing and shellfish; Agriculture includes forestry and silviculture;

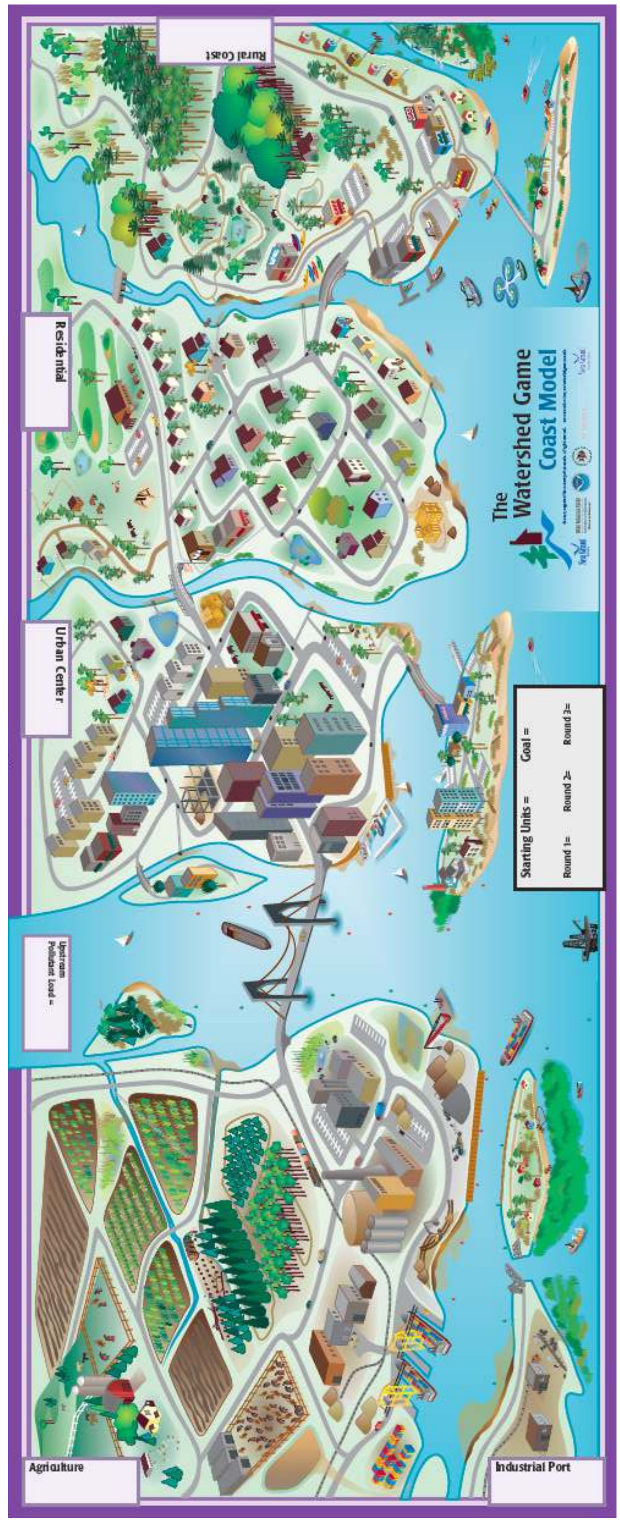

Figure 3. Watershed Game Coast Model game board.

Urban Center includes a marina, recreation, and barrier island with heavy tourism; Residential incorporates wastewater issues and water supply issues by including a dam; and Rural Coast includes a traditional working waterfront, aquaculture, recreation/tourism, and undeveloped areas. The design of the coastal game board also allowed the team to incorporate coastal impacts not ubiquitous to all coasts, but critical regionally (e.g., an oil drilling platform, aquaculture pens, channelized wetlands) that could be used as teaching opportunities where appropriate.

Flooding and Resilience

Based on the review of reports, focus group discussions, and surveys, the project development team noted that a variety of the coastal challenges identified through this study contribute to or manifest as flooding. This includes stormwater-related flooding from upstream (exacerbated by land uses, wetland destruction, and climate change effects on storm frequency and severity) and coastal flooding (exacerbated by severe storms, sea level rise, loss or degradation of coastal lands and wetlands, and development practices). As the team considered how to best address flooding in game design, the concept of coastal resilience emerged as a critical aspect, and an issue that many Sea Grant programs and local governments are addressing in coastal regions. In reviewing survey data, the team concluded that there was sufficient evidence to support integrating resilience into the Coast Model. Riverine and coastal flooding (including coastal land loss and sea level rise) could best be addressed by helping communities increase their ability to plan for, respond to, and recover from flooding events (i.e., increase their resilience to flooding). Thus, each Tool Card, in addition to featuring scores for pollution reductions (PUs) for nitrogen, phosphorus, and sediment, includes a score for increased resilience (RUs). During game play, teams are incentivized to increase their land use's resilience by selecting tools that decrease the likelihood of possible damages from flooding, while also reducing their nonpoint source pollution load. The system is modeled after the Federal Emergency Management Act's Community Rating System, a voluntary incentive program that recognizes and encourages community floodplain management practices that exceed the minimum requirements of the National Flood Insurance Program.

Conclusions

We anticipate that the Coast Model of the Watershed Game will be used as an extension tool throughout U.S. coasts to help decision-makers and students learn how to better manage complex coastal ecosystems through collaborative, informed problem-solving. As such, it meets Sea Grant's mission to support and communicate science in a practical, actionable manner and to integrate research into engagement. We envision that the new Coast Model of the Watershed Game will join the original games as tools for resource managers, planners, and educators to empower communities, helping individuals learn about practices, plans, and policies that improve and protect the health of the environment, the quality of the water, and the ways communities can prepare for, respond to, and recover from flooding in coastal areas.

Used in combination, the multiple data collection methods described in this paper provide a case study of how to effectively query a variety of researchers, outreach professionals, and practitioners about the priority water resource management challenges. In this case, results provided a solid foundation for developing an interactive outreach tool, the Coast Model of the Watershed Game. The variety of methods offered a greater range and depth of information for enhanced understanding and credibility of findings. Results from the assorted approaches helped elucidate different aspects of coastal issues from varying perspectives, provided an enhanced understanding of the nuances of the challenges related to coastal environments, and allowed the project development team to identify issues common across multiple coastal areas of the U.S. When viewed together, the combined results showed a high level of agreement across methodologies and revealed important opportunities to facilitate the integration of water quality and resilience to flooding. Resilience to flooding is a significant addition to the Coast Model of the Watershed Game and allows game facilitators to introduce and discuss the diverse challenges associated with flooding, community resilience, and ultimately, climate change. The Coast Model of the Watershed Game is a serious game that supports collaborative, inclusive approaches to watershed management in coastal areas. The sequential, multi-pronged approach to gathering and synthesizing coastal expertise provides a model for others seeking to unify communities around watershed-scale management challenges.

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References

Anderson, D.M., P.M. Glibert, and J.M. Burkholder. 2002. Harmful algal blooms and eutrophication: Nutrient sources, composition, and consequences. *Estuaries* 25(4): 704-726.

Arndt, D.S. and D.S. LaDue. 2008. Applying concepts of adult education to improve weather and climate literacy. *Physical Geography* 29(6): 487-499. Available at: https://doi.org/10.2747/0272-3646.29.6.487. Accessed November 1, 2021.

Bathke, D.J., T. Haigh, T. Bernadt, N. Wall, H. Hill, and A. Carson. 2019. Using serious games to facilitate collaborative water management planning under climate extremes. *Journal of Contemporary Water Research & Education* 167(1): 50-67.

Bilotta, J. and C. Hagley. 2017. The Watershed Game generating public value for over ten years. Available at: https://conservancy.umn.edu/handle/11299/193355. Accessed November 1, 2021.

Boehlje, M.D. and V.R. Eidman. 1978. Simulation and gaming models: Application in teaching and extension programs. *American Journal of Agricultural Economics* 60(5): 987-992. Available at: https://doi.org/10.2307/1240134. Accessed November 1, 2021.

Brehm, J., B. Eisenhauer, and R. Krannich. 2004. Dimensions of community attachment and their relationship to well-being in the amenity-rich rural west. *Rural Sociology* 69(3): 405-429.

Burby, R.J. 2003. Making plans that matter: Citizen involvement and government action. *Journal of the American Planning Association* 69(1): 33-49. Available at: https://www.tandfonline.com/doi/abs/10.1080/01944360308976292. Accessed November 1, 2021.

Dewey J. 1938. *Experience and Education*. Macmillan, New York, NY.

Falk, J.H., E. Donovan, and R. Woods (Eds.). 2001. *Free-choice Science Education: How We Learn Science Outside of School*. Teachers College Press, New York, NY.

Gray, J.S. 1997. Marine biodiversity: Patterns threats and conservation needs. *Biodiversity and Conservation* 61: 153-175.

Hidalgo, C. and B. Hernandez. 2001. Place attachment: Conceptual and empirical questions. *Journal of Environmental Psychology* 21: 273-281.

Hoekstra, A.Y. 2012. Computer-supported games and role plays in teaching water management. *Hydrology and Earth System Science* 16: 2985-2994. Available at: https://doi.org/10.5194/hess-16-2985-2012. Accessed November 1, 2021.

Lotze, H.K., H.S. Lenihan, B.J. Bourque, R.H. Bradbury, R.G. Cooke, M.C. Kay, and J.B. Jackson. 2006. Depletion degradation and recovery potential of estuaries and coastal seas. *Science* 3125781: 1806-1809.

Mayer, I.S. 2009. The gaming of policy and the politics of gaming: A review. *Simulation & Gaming* 40(6): 825-862. Available at: https://doi.org/10.1177%2F1046878109346456. Accessed November 1, 2021.

Medema, W., A. Furber, J. Adamowski, Q. Zhou, and I. Mayer. 2016. Exploring the potential impact of serious games on social learning and stakeholder collaborations for transboundary watershed management of the St. Lawrence River Basin. *Water* 8(5): 175. Available at: https://doi.org/10.3390/w8050175. Accessed November 1, 2021.

Minnesota Sea Grant. 2019. University of Minnesota Sea Grant College Program: Briefing Book. Available at: https://seagrant.umn.edu/sites/seagrant.umn.edu/files/2020-11/2019-SeaGrantBriefingBook.pdf. Accessed November 1, 2021.

Nanzer, B. 2004. Measuring sense of place: A scale for Michigan. *Administrative Theory and Praxis* 26(3): 362-382.

Oblinger, D. 2004. The next generation of educational engagement. *Journal of Interactive Media in Education* 8: 1-18.

Oelsner, G.P. and E.G. Stets. 2019. Recent trends in nutrient and sediment loading to coastal areas of the conterminous U.S.: Insights and global context.

Science of the Total Environment 654: 1225-1240.

Peters, V.A. and G.A. Vissers. 2004. A simple classification model for debriefing simulation games. *Simulation & Gaming* 35(1): 70-84.

Reckien, D. and K. Eisenack. 2013. Climate change gaming on board and screen: A review. *Simulation & Gaming* 44: 253-271.

Rumore, D., T. Schenk, and L. Susskind. 2016. Role-playing simulations for climate change adaptation education and engagement. *Nature Climate Change* 6: 745-750. Available at: https://www.nature.com/articles/nclimate3084?proof=t. Accessed November 1, 2021.

Rusca, M., J. Heun, and K. Schwartz. 2012. Water management simulation games and the construction of knowledge. *Hydrology and Earth System Science* 16: 2749-2757. Available at: https://hess.copernicus.org/articles/16/2749/2012/. Accessed November 1, 2021.

Stets, E.G., L.A. Sprague, G.P. Oelsner, H.M. Johnson, J.C. Murphy, K. Ryberg, A.V. Vecchia, R.E. Zuellig, J.A. Falcone, and M.L. Riskin. 2020. Landscape drivers of dynamic change in water quality of U.S. rivers. *Environmental Science Technology* 54: 4336-4343.

Thompson, A.W. and L.S. Prokopy. 2016. The role of sense of place in collaborative planning. *Journal of Sustainability Education* 11: 1-19. Available at: http://www.jsedimensions.org/wordpress/wp-content/uploads/2016/03/ThompsonPropoky-11-Issue-JSE-Feb-2016.pdf. Accessed November 1, 2021.

Uitto, J.I. and A.M. Duda. 2002. Management of transboundary water resources: Lessons from international cooperation for conflict prevention. *The Geographical Journal* 168(4): 365-378.

U.S. Environmental Protection Agency (U.S. EPA). 2017. *National Water Quality Inventory: Report to Congress*. EPA 841-R-16-011. Available at: https://www.epa.gov/sites/production/files/2017-12/documents/305brtc_finalowow_08302017.pdf. Accessed November 1, 2021.

Van Bilsen, A., G. Bekebrede, and I. Mayer. 2010. Understanding complex adaptive systems by playing games. *Informatics in Education* 9: 1-18.

Appendix A: Review of Reports Cited

Alabama Coastal Management Program. (2015). Alabama Coastal Area Management Program Section 309 Assessment and Strategies 2016-2021.

The Coastal Protection and Restoration Authority (CPRA). (2017). Louisiana's Comprehensive Master Plan for a Sustainable Coast.

The Coastal Regional Commission. (2014). Regional Assessment of Coastal Georgia.

The Coastal Zone Management Program. (2017). National Coastal Zone Management Program Enhancement Program Synthesis (2016-2020).

Eastern Research Group, Inc. (ERG). (2014). Insights into Coastal Management Needs: Results from the NOAA Coastal Services Center and Office of Ocean and Coastal Resource Management Customer Survey.

Florida Coastal Management Program. (2015). Florida Coastal Management Program Section 309 Assessment and Strategies 2016-2020.

Florida Department of Environmental Protection's Office of Coastal and Aquatic Managed Areas. (2013). Apalachicola National Estuarine Research Reserve Management Plan.

Florida Department of Environmental Protection's Office of Coastal and Aquatic Managed Areas. (2009). Guana Tolomato Matanzas National Estuarine Research Reserve Management Plan 2009-2015.

Georgia Coastal Management Program. (2015). Georgia Coastal Management Program Section 309 Assessment and Strategy 2016 to 2020.

Georgia Department of Natural Resources: Coastal Resources Division. (2012). Accomplishments of the Georgia Coastal Management Program Report.

Grand Bay National Estuarine Research Reserve. (2013). Grand Bay NERR Management Plan 2013-2018.

The Gulf of Mexico Alliance. (2016). Governors' Action Plan III for Healthy and Resilient Coasts (2016-2021).

Louisiana Coastal Management Program. (2015). Louisiana Coastal Management Program Section 309 Assessment and Strategy 2016-2020.

Louisiana State University Coastal Sustainability Studio- Community Planning & Louisiana Sea Grant. (n.d.). Vulnerability and Resilience in Threatened Coastal Louisiana Communities.

Mission Aransas NERR prepared by University of Texas Marine Science Institute. (2015). Mission Aransas National Estuarine Research Reserve Management Plan 2015-2020.

Mississippi Coastal Program. (2015). Mississippi Coastal Program Coastal Zone Management Act &

309 Assessment and Strategy 2016-2020.

Mississippi Department of Environmental Quality. (2015). Watershed Implementation Plan Rotten Bayou.

The Mobile Bay National Estuary Program. (2013). Comprehensive Conservation and Management Plan for Alabama's Estuaries & Coasts 2013-2018.

National Oceanic and Atmospheric Administration. (2015). A Strategy for a Healthy Gulf of Mexico: Resilience Through Ecosystem Restoration.

The Nature Conservancy Florida. (2014). Perdido Bay Community Based Watershed Plan.

NOAA's National Marine Fisheries and the Environmental Protection Agency's Wetland Division. (2015). Coastal Wetlands Initiative: Gulf of Mexico Review.

North-Inlet Winyah Bay NERR. (2011). North Inlet-Winyah Bay National Estuarine Research Reserve Management Plan 2011-2016.

Office of Governor John Bel Edwards. (2018). Louisiana Watershed Initiative: A Long-term Vision for Statewide Sustainability and Resilience.

Sapelo Island National Estuarine Research Reserve (NOAA). (2007). Sapelo Island National Estuarine Research Reserve Management Plan (2008-2013).

South Carolina Coastal Management Program. (2015). South Carolina Coastal Area Management Program Section 309 Assessment and Strategies 2016-2022.

South Carolina Sea Grant. (2017). The Changing Face of Coastal South Carolina: Building a Resilient Future Strategic Plan FY2018-FY2021.

The University of Georgia Marine Extension and Georgia Sea Grant. (2016). The University of Georgia Marine Extension and Georgia Sea Grant's 2018-2021 Strategic Plan.

Van Dolah, R.F., D.M. Sanger, G.H.M. Riekerk, S.E. Crowe, M.V. Levisen, D.C. Bergquist, D.E. Chestnut, W. McDermott, M.H. Fulton, E. Wirth. (2013). The Condition of South Carolina's Estuarine and Coastal Habitats During 2009-2010. (Technical Report No. 107). Charleston, SC: South Carolina Marine Resources Division.

Volkert, Inc. contracted by Mobile Bay National Estuary Program prepared for the City of Foley, City of Gulf Shores, Mobile Bay NEP. (2017). Bon Secour River, Oyster Bay, Skunk Bayou Watershed Management Plan.

Weeks Bay NERR. (2017). Weeks Bay National Estuarine Research Reserve Management Plan 2017-2022.

Appendix B: Survey Instrument

Q1: Which of the following items do you consider to be critical challenges currently impacting the lands and waters along your coast? (check ALL that apply)

- Excess sediment
- Coastal land loss
- Excess phosphorus
- Excess nitrogen
- Nutrients
- Pathogens
- Harmful algal blooms
- Fecal coliform
- Erosion
- Flooding
- Excess flow
- Resilience
- Elevated water temperatures
- Salt water intrusion
- Other (please specify)

Q2: Of the challenges you identified in Question One, which do you consider to be the NUMBER 1 CHALLENGE in terms of overall potential impacts to the natural and socioeconomic environments along your coasts? (choose ONE)

- Excess sediment
- Coastal land loss
- Excess phosphorus
- Excess nitrogen
- Nutrients
- Pathogens
- Harmful algal blooms
- Fecal coliform
- Erosion
- Flooding
- Excess flow
- Resilience (*omitted from Regional Survey)
- Elevated water temperatures
- Salt water intrusion
- Other (please specify)

Q3: Of the challenges you identified in Question One, which do you consider to be the NUMBER 2 CHALLENGE in terms of overall potential impacts to the natural and socioeconomic environments along your coasts? (choose ONE)

- Excess sediment
- Coastal land loss
- Excess phosphorus
- Excess nitrogen
- Nutrients
- Pathogens
- Harmful algal blooms
- Fecal coliform

- Erosion
- Flooding
- Excess flow
- Resilience (*omitted from Regional Survey)
- Elevated water temperatures
- Salt water intrusion
- Other (please specify)

Q4: Of the challenges you identified in Question One, which do you consider to be the NUMBER 3 CHALLENGE in terms of overall potential impacts to the natural and socioeconomic environments along your coasts? (choose ONE)

- Excess sediment
- Excess phosphorus
- Excess nitrogen
- Nutrients
- Pathogens
- Harmful algal blooms
- Fecal coliform
- Erosion
- Coastal land loss
- Flooding
- Excess flow
- Resilience (*omitted from Regional Survey)
- Elevated water temperatures
- Salt water intrusion
- Other (please specify)

Q5: Considering the #1 challenge you identified in Question Two, what are the primary land uses that contribute to this challenge? (check ALL that apply)

- Agriculture
- Forestry/silviculture
- Heavy industry
- Urban and residential, including wastewater
- Aquaculture
- Fishing (subsistence, recreational, or commercial)
- Ports and harbors
- Beaches and marinas
- Oil and gas exploration and extraction
- Flood control
- Recreation and tourism
- Other (please specify)

Q6: Considering the #2 challenge you identified in Question Three, what are the primary land uses that contribute to this challenge? (check ALL that apply)

- Agriculture
- Forestry/silviculture
- Heavy industry
- Urban and residential, including wastewater
- Aquaculture
- Fishing (subsistence, recreational, or commercial)
- Ports and harbors
- Beaches and marinas
- Oil and gas exploration and extraction
- Flood control
- Recreation and tourism
- Other (please specify)

Q7: Considering the #3 challenge you identified in Question Four, what are the primary land uses that contribute to this challenge? (check ALL that apply)

- Agriculture
- Forestry/silviculture
- Heavy industry
- Urban and residential, including wastewater
- Aquaculture
- Fishing (subsistence, recreational, or commercial)
- Ports and harbors
- Beaches and marinas
- Oil and gas exploration and extraction
- Flood control
- Recreation and tourism
- Other (please specify)

Q8: Please share any other clarifying comments about or descriptions of the challenges that concern you relative to coastal environments.

Q9: In your opinion, what are the highest priority practices, plans, or policies that are used or should be used to address these challenges (e.g., restoration of impacted habitats, improved resiliency planning, pollution trading, etc.)? Please be brief with your answers.

Regional Survey Q10: How would you best characterize your professional or organizational affiliation? (check ALL that apply)

- Sea Grant or Cooperative Extension
- Research/Academia
- NGO/Non-Profit
- State Government
- Private Sector
- County Government
- Federal Government
- Local Government
- National Estuary Program
- Regional Government
- National Estuarine Research Reserve
- Media
- Military
- International
- Tribal Government
- Other

Regional Survey Q11: How would you describe your professional role? (check ALL that apply)

- Teacher/Educator

- Outreach Specialist
- Research Scientist
- General Stakeholder/Resident
- Natural Resource Manager
- Environmental Consultant
- Planner
- Journalist/Communications Specialist
- Policymaker
- Tourism Specialist
- Business Owner
- Land Conservation Specialist
- Member of the Fishing Community or Industry
- Public Land Manager
- Agricultural Community Member
- Emergency Responder/Manager
- Elected Official
- Energy Industry Member
- Health Professional
- Port or Harbor Manager
- Public Health Official
- Tribal Representative
- Other

Sea Grant Survey Q10: What state do you primarily work in?