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Conceptual and Technological Advancements in Visitor Use Management of Coastal and Estuarine Environments

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CONCEPTUAL AND TECHNOLOGICAL ADVANCEMENTS IN VISITOR USE MANAGEMENT OF COASTAL AND ESTUARINE ENVIRONMENTS

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ABSTRACT

This dissertation demonstrates the exploration and use of conceptual and technological advancements in the science of visitor use management (VUM). The goal of this effort is to help better understand visitors to park and protected areas (PPAs) and more specifically, better manage our coastal and estuarine environments (i.e., coastal protected areas (CPAs). These concepts and techniques are 1) further implementing the use of location-based services data in recreation ecology and visitor use management, 2) assessing the use of advanced imagery, virtual reality (VR), in visual-based methods to determine visitor indicators and thresholds, and 3) assessing visitor's awareness of PPAs and how it influences their perceptions, attitudes, and behaviors towards recreation impacts and management. As visitation evolves, so must the techniques and management strategies of PPAs. Equipped with new understanding and technologies, researchers and managers alike will be able to better understand visitation and its impacts on both the social and ecological aspects of CPAs. Results from Chapter 2 demonstrate the potential for the use of mobile data in VUM and the considerations necessary to utilizing these data sources. The results from Chapter 3 find that the acceptability for the expansion of oyster mariculture in South Carolina can be influenced by a relatively limited amount of information if given to the public. This chapter also explored the efficacy of VR technologies in field-based survey research and outlines best practices. Results from Chapter 4 conceptualizes, measures, and assesses a newly created Visitor Awareness Index (VAI) and finds modest differences in visitor perceptions and characteristics among the sample but opens the door for further research.

The concepts and techniques explored throughout this dissertation not only adds to the current knowledge but will help develop best practice techniques for CPA managers. The use of these techniques has been growing in other fields of research and they should be explored in the context of PPA management. To better manage and protect our coastal areas protected area researchers and managers must find better ways to understand visitor use and its impacts.

DEDICATION

To my family and friends who have supported me throughout this journey

ACKNOWLEDGMENTS

As much as a dissertation is thought of as an individual accomplishment, this work was truly a team effort and there are many who deserve my sincerest gratitude and acknowledgement. First and foremost, Dr. Jeffrey Hallo, my committee chair, whose persistence, and guidance kept this ship afloat. Dr. Hallo's willingness to brainstorm and collaborate made me a better thinker and writer, and for that I thank you. I'd like to thank Dr. Matthew Brownlee for being a guiding light throughout my entire graduate school journey. Dr. William Norman's willingness to share his wealth of knowledge and guidance has also been unmatched during my time at Clemson University. I'd also like to thank Dr. Elizabeth Forys. A professor I've known since undergraduate school, her passion for teaching and student engagement has been a model that I consistently aspire to.

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CHAPTER 1

INTRODUCTION

Coastal tourism is the most popular form of travel in the United States (Houston, 2018; Klein, & Osleeb, 2010). In 2017, 205 million Americans made 2.3-billion-day visits to beaches alone (U.S. Census Bureau, 2017a, b). The term *coastal counties* has been used to focus research efforts involving human dimensions along the coast (Ache et al., 2015). The National Oceanic and Atmospheric Administration (NOAA) defines coastal counties as being either Coastal Watershed Counties, "…where land use and water quality changes most directly impact coastal ecosystems" or as Coastal Shoreline Counties, "…that are directly adjacent to the open ocean, major estuaries, and the Great Lakes." (Ache et al., 2015, p. S152). As of 2018, about 128 million people, or almost 40% of the total U.S. population, live within the shoreline counties of the lower forty-eight states, and as of the most recent census numbers, a 15.3% growth in population has been seen since 2000 in this region (U.S. Census Bureau, 2019). These counties, however, only account for about 10% of the total landmass in the continental U.S. (Ache et al., 2015). In the Southeast of the United States (i.e., N. Carolina, S. Carolina, Georgia, & Florida), shoreline counties make up 29.3% of the total landmass. Of that 29.3%, only 25.9% of the total land within shoreline counties is protected by either federal, state, or local governments, NGOs, or by private citizens through land trusts and easements (Epanchin-Niell et al., 2017).

Natural lands in coastal areas, particularly those found in coastal protected areas (CPAs) provide a plethora of ecosystem services that other, non-coastal parks and

protected areas (PPAs) may not. These ecosystem services include storm surge attenuation, carbon storage, floodwater retention, water quality enrichment, critical spawning and nesting habitat, and recreational opportunities (Barbier et al., 2011; Riungu et al., 2020; Spalding et al., 2014). Although these benefits can be hard to visualize and somewhat abstract, there have been many attempts to put monetary values to the ecosystem services that coastal lands can provide (Barbier et al., 2001; Bell, 1997; Costanza et al., 2008; Epanchin-Niell et al., 2017; Gedan et al., 2009; Houston, 2018; Kulczyk et al., 2018; Vallecillo et al., 2019). CPAs are locations where the benefits of these ecosystem services are abundant, which is why these places are so important. However, for the purpose of this dissertation, the ecosystem service that will be focused on are the opportunities for recreation and how visitors interact with CPAs.

These coastal environments not only allow for visitors to participate in traditional water-based recreation (e.g., boating, paddling, swimming, and fishing) but offer unique wildlife viewing experiences that may not be possible elsewhere (i.e., shorebird and sea turtle nesting). These opportunities come with specific management challenges like accurately counting visitors, assessing their impacts on CPAs, and determining their unique perceptions of CPA management.

Gauging visitation to CPAs is a complex issue. Due to the dynamic nature of these areas, open or porous boundaries, and countless access points, it can be quite difficult to determine the true number of visitors to many CPAs (Merrill et al., 2020). These dynamic landscapes also lend themselves to visitors not even knowing that they are recreating within a protected area (Blotkamp et al., 2011; Manni et al., 2013) because of poor or inadequate signage to inform them of protected area boundaries and

management regulations (Martin et al., 2015). Also, visitors may not know they are in a protected area because of their unfamiliarity with the area they are visiting (i.e., out-of-town visitors and tourists) (Cook & Le, 2015). These factors make it even more difficult for CPA managers to determine and monitor visitor use.

In the pursuit to manage "acceptable park uses" (McKercher, 1996, p.576), federal land managers from the Bureau of Land Management, the National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, National Oceanic and Atmospheric Administration, and U.S. Army Corps of Engineers came together in 2016 to create the Interagency Visitor Use Management Council (IVUMC). As the federal leader in visitor use management, the purpose of this council is to 1) develop interagency guidance for effective visitor use management programs that are efficient and legally defensible, 2) identify strategies for improving institutional capabilities and professional competencies, including partnerships, 3) Develop shared tools and training, including a unified visitor use planning framework, and monitor their effectiveness, and 4) improve internal and external communication strategies (IVUMC, 2016). Drawing from concepts and frameworks from previous visitor use research (e.g., Limits of Acceptable Change, LAC, and Visitor Experience and Resource Protection, VERP). The Interagency Visitor Use Management Framework (IVUMF) was created as a "management toolbox" that managers could rely on to solve visitor impact issues (IVUMC, 2016). The four-element approach (Figure 1.1) provides "cohesive guidance on the major elements for analyzing and managing visitor use on federally managed lands and waters." (IVUMC, 2016, p. 3).

The four major elements that the framework is divided into are: 1) build the foundation, 2) define visitor use management direction, 3) identify management

strategies, and 4) implement, monitor, evaluate, and adjust. In step one, the project need is clarified, and the area of interest is defined before assessing current conditions and developing a plan of action. Step two identifies the desired conditions for that location, appropriate visitor activities, facilities, and services, then selects indicators and establishes thresholds. Indicators are measurable and manageable variables that help define the quality of a recreation experience, whereas a threshold represents the minimum acceptable condition of an indicator (Cribbs et al., 2020). Step three compares the existing conditions to the desired conditions, then identifies management efforts and monitoring strategies to help achieve the desired conditions. Finally, step four implements the decided management actions, then conducts ongoing monitoring to evaluate the effectiveness of the management actions and adjust the strategy should the need arise (IVUMC, 2016). At the core of the IVUMF is the need to measure indicators and thresholds to provide both sound rationale for new management decisions and management of acceptable park uses.

Assessing visitor impacts to PPAs using traditional techniques is typically a very time-consuming process. One tool that has been essential to managing visitor use has been visitor surveys. Visitor surveys are conducted to help formulate indicators and thresholds to guide visitor use management and determine visitor attitudes towards potential management alternatives. The objectives of these surveys are often to determine 1) the relative importance of the indicator variables identified by users, 2) normative thresholds for selected indicators (e.g., people at one time or mariculture expansion), and 3) visitors' attitudes toward alternative or potential management practices and services. When appropriate, visual approaches to measuring thresholds can be employed using

computer-generated photographs to represent a range of visitor-caused impacts. This approach has been widely used in the development of thresholds in protected areas (Cribbs et al., 2019; Cribbs et al., 2020; Graefe et al., 1984; Hallo et al., 2018; Manning, 2022). Visitor attitudes toward management actions can also be measured by asking the extent to which respondents favor or oppose a series of alternative management practices or services designed to maintain thresholds. Potential management alternatives and services can be identified in coordination with managers, and may include both resource management practices (e.g., resource allocation, facility development, site closures) and visitor management practices (e.g., information/education, rules and regulations, permitting, fees, use limits, development of new services).

Measuring visitors' perceptions of management is one way PPAs can assess how visitors react to managers' decisions. PPA managers and researchers have both used visual-based methods to help understand visitors' preferences for a range of conditions (Cribbs et al., 2019; Daniel & Boster, 1976; Manning, 2007; Ribe, 1989; Shuttleworth, 1980). One of the most common visual-based methods is using a series of ordered photographs to display different conditions of varying severity. (e.g., Cribbs et al., 2019; Dalton et.al., 2017; Freimund, et al., 2002; Hallo et al., 2018; Krymkowski et al., 2009; Manning et al., 1996; Manning et al., 1999; Manning, 2022; Manning & Freimund, 2004; Needham & Rollins, 2005; Needham et al., 2011). Photographs have been found useful because they are suggestive surrogates when classifying different conditions and help visitors to "imagine" a range of conditions (Newman et al., 2001). Although effective, there are methodological issues with this process. For example, two-dimensional (2D) photos may only portray limited sensory information, which may create difficulties when

developing accurate indicators and thresholds. This has opened the door to exploring new methods and technologies when attempting to assess stakeholder perceptions.

Another tool that has become more popular as technology becomes cheaper and easier to use is the implementation of field cameras for the purposes of visitor monitoring and data collection. These cameras can be deployed to count recreation users and determine use timing at various locations throughout PPAs. These cameras are typically purchased and used by individuals for recording wildlife activity. These cameras are both reliable and field-tested for the purposes of automatically recording recreation use at a site (Cribbs et al., 2019; Little et al., 2020; Sharp et al., 2019; Sunger, et al., 2012). Field cameras offer the advantage of allowing for much more detailed and robust data collection since they are not reliant on an individual being present at the site. Also, these cameras have a programmable time-lapse function that allows photos to be taken systematically at specified intervals and during specified hours. These cameras are often weatherproof and designed to be easily mounted in natural settings.

A newer trend in visitor use management has been the deployment of GPS-based visitor monitoring. These efforts are used to understand visitors' travel patterns throughout PPAs, time spent in specific locations, and spatial distributions of use. Sampling efforts are typically conducted by stationing a research assistant on randomly selected days (stratified by weekday versus weekend) at various locations throughout the PPA. Visitors to these locations will be asked by investigators to carry a small GPS monitor (i.e., data loggers) throughout their experience. This technology allows for an accurate view of the temporal and spatial use of the study area, and differences in patterns

of use between activities (Beeco et al., 2014; Peterson et al., 2020; Sharp et al., 2019). GPS data can then be mapped for hotspots of use using ESRI GIS software.

Each of these measurements are greatly important in their own right when it comes to managing PPAs and CPAs to ensure both proper conservation efforts and visitor experience goals are being met. Although these traditional method to data collection can be highly accurate, they can suffer from being time consuming and costly. Due to these downfalls, monitoring efforts may not happen as regularly as needed and can be overshadowed by day-to-day operations and management challenges, causing a severe lack in spatial and temporal data to inform adaptive management strategies (Manning, 2022). Implementing new, technology-based strategies and techniques may aid in making better and more effective management decisions for CPAs and PPAs as a whole.

Purpose Statement and Research Questions

This dissertation aims to advance the science of visitor use management (VUM) in CPAs and help protect coastal natural resources. The overall goal of this research is to evaluate the effectiveness and efficacy of emerging technologies and concepts by applying them to protected area management and visitor use management, particularly in a coastal setting. More specifically, the technological and conceptual applications that are explored in this dissertation are:

1. Further implementing the use of location-based services data in recreation ecology and visitor use management in answering detailed management questions;

   a. How do location-based services (LBS) methods compare to field camera methods for the determination of visitor use levels across several CPA management areas (i.e., higher-use area, low use backcountry areas, and wildlife habitat area) and over the course of an entire use season?
   b. Can LBS data be used to measure outcomes of physical interventions (i.e., symbolic fencing) to manage visitor use in a CPA?
   c. Can LBS data be used to measure outcomes of policy interventions (i.e., seasonal restrictions and area closures) to manage visitor use in a CPA?

2. Assessing the use of advanced imagery in visual-based methods (head-mounted displays used for creating a virtual reality experience) to determine visitor indicators and thresholds;

   a. What are stakeholders' perceptions of oyster maricultural development, and related issues and benefits, in coastal South Carolina waterways?
   b. What are the norm-based thresholds for viewing oyster mariculture operations from different distances, of different sizes, arrangements, and in varying contexts (i.e., viewed from a dock or within view of a major transportation bridge)?
   c. What issues and advantages emerge for survey respondents and researchers in using VR/360° imagery to measure social norms in a field-based setting?

3. Creation of a Visitor Awareness Index to better understand visitor use and how this awareness matters in PPA management;

a. What dependent variables constitute a holistic approach to measuring visitor awareness?
b. Based on a Visitor Awareness Index score:
    i. What types of visitors are more aware than others?
    ii. How does visitor awareness influence place-based perceptions (i.e., how crowding is felt among visitors)?
c. What management actions (i.e., access to parking, interactions with staff, and educational programing) can promote visitor awareness?

As visitation evolves, so have the techniques and management strategies of protected areas. Equipped with new technologies and concepts, researchers and managers alike will be able to better understand visitation and its impacts on both the social and ecological aspects of CPAs.

The assessment of techniques throughout this dissertation will not only add to the current knowledge but will help develop best practice techniques for CPA managers and researchers. The use of these techniques has been growing in other fields of research and they should be explored in the context of protected area management. To better manage and protect our coastal areas we must find better ways to understand visitor use and its impacts.

Study Sites

Chapters 1 & 3

The ACE Basin National Estuarine Research Reserve (NERR) is a 94,621-acre estuary located in Beaufort, Colleton, and Charleston Counties in southeast South

Carolina. Officially placed under private (i.e., through conservation easements), state, and federal protection in 1992, the ACE Basin NERR is home to a vast network of coastal environments including saltwater and brackish-water marshes, maritime forest, upland pine, and bottomland hardwood forests. Due to the number of unique habitats within ACE Basin NERR, the reserve is considered one of the most ecologically diverse locations in all the U.S. Atlantic Coast, which according to the reserve creates unique recreational opportunities found in few other public lands and waterways (Maier, 2010).

Chapter 2

Communities and waterfronts near areas open to mariculture permitting will also be a focus area of this dissertation. Mariculture is defined as the controlled cultivation of shellfish in confinement from seed size (<=1 inch) until harvest (South Carolina Department of Natural Resources, 2000, Section 50-5-15). Public boat launches, coastal recreational facilities (i.e., public parks, boardwalks, fishing piers, beaches), and festivals and events within Charleston and Beaufort counties, South Carolina will provide access to intercoastal stakeholders. These stakeholders include coastal residents, intercoastal property owners, tourists (those who reside outside of the study counties), recreational boaters, and recreational anglers/shellfishers.

Definitions

Coastal Protected Areas (CPAs):

> Federal, state, and local governments in the United States, along with land trusts and other nonprofit organizations protecting natural lands in coastal areas (i.e., natural lands in coastal areas, including beaches, dunes, wetlands, and forests; Epanchin-Niell et al., 2017)

Indicators:

Specific resource or experiential attributes that can be measured to track changes in conditions so that progress towards achieving and maintaining desired conditions can be assessed (IVUMC, 2016)

Location-based Services (LBS):

Services that integrate a mobile device's location or position with other information so as to provide added value to a user (Schiller and Voisard, 2004)

Mariculture:

The farming of aquatic organisms in saltwater environments (Food & Agriculture Organization, 2004).

Potential for Conflict Index:

The Potential for Conflict Index (PCI) was developed to facilitate understanding and applicability of human dimensions findings to managerial concerns.

PCI ranges from 0 (minimal) to 1 (maximum) potential for conflict and simultaneously describes a variable's central tendency, dispersion & shape using a graphic display (Vaske et al., 2010)

Social Acceptability:

Standards that individuals use for evaluating their acceptance of increasing numbers of encounters with other people, objects, or behaviors before degrading their experience (Manning, 2022)

Social Carrying Capacity:

The traditional body of knowledge developed by managers and scientists to address the negative impacts of visitation to resource and social conditions (Marion, 2016)

Thresholds:

The minimally acceptable conditions associated with each indicator (IVUMC, 2016)

Visitor Awareness Index (VAI):

An index developed by Cribbs et al. to measure the level of awareness a park and protected area visitor has about the place that they are visiting.

Visual-based Methods:

A collection of methods that incorporate visual elements such as maps, drawings, photographs, videos, as well as three-dimensional objects into the research process to elicit responses (Manning, 2022)

Visitor Estimation:

Measuring and monitoring use levels in parks and protected areas

Virtual Reality (VR):

The use of computer modeling and simulation that enables a person to interact with an artificial three-dimensional (3-D) visual or other sensory environment (Armougum et al., 2019)

Visitor Use Management:

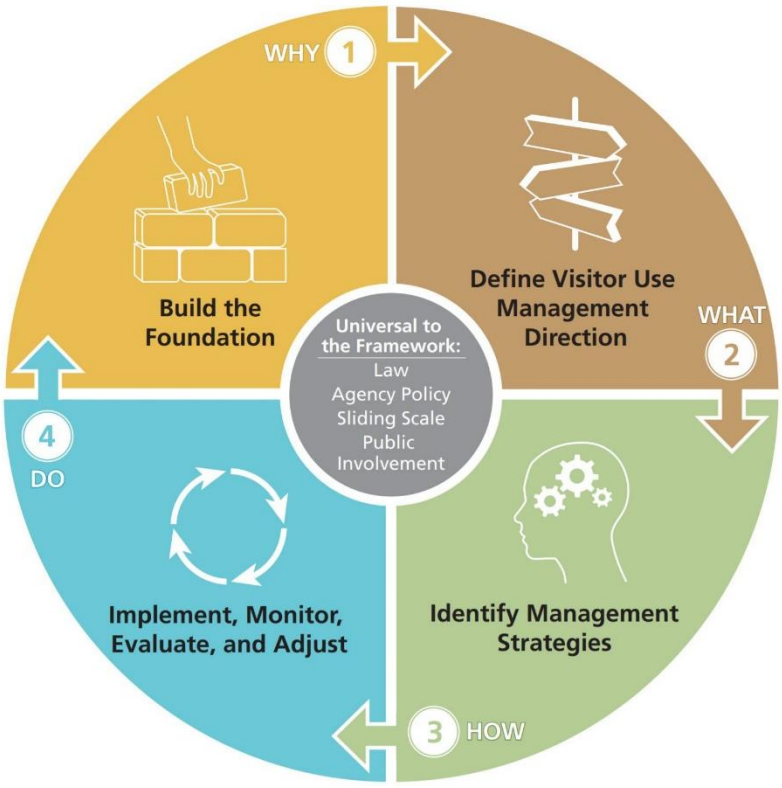
> The proactive and adaptive process for managing characteristics of visitor use and the natural and managerial settings using a variety of strategies and tools to achieve and maintain desired resource conditions and visitor experiences. Simply put, it means managing use well to provide sustainable recreation opportunities (IVUMC, 2016).

Structure of the Document

The rest of this document contains three chapters, each addressing research questions and formatted as journal manuscripts with appendices (as needed) and references for each chapter. The first of these chapters is titled: *Using Location-Based Services (LBS) Data to Identify and Assess Visitor Related Management Actions in a Coastal Protected Area.* The second of these chapters is titled: *Social Carrying Capacity of Oyster Mariculture on the Coast of South Carolina: Understanding Stakeholders Perceptions and Thresholds for Oyster Mariculture Development.* The last of the three chapters is titled: *Visitor Awareness: The Conceptualization and Measurement of a Visitor Awareness Index.* The chapters each include an introduction, literature review, a description of methods and analysis, results, discussion, and a reference list. Finally, a summary chapter will recap the findings of this dissertation, the implications of these findings, and what future research could be conducted.

FIGURES

Figure 1. 1: Overview of the Visitor Use Management Framework (IVUMC, 2016)



REFERENCES

Ache, B. W., Crossett, K. M., Pacheco, P. A., Adkins, J. E., & Wiley, P. C. (2015). "The coast" is complicated: a model to consistently describe the nation's coastal population. *Estuaries and Coasts*, 38(1), 151-155.

Armougum, A., Orriols, E., Gaston-Bellegarde, A., Joie-La Marle, C., & Piolino, P. (2019). Virtual reality: A new method to investigate cognitive load during navigation. *Journal of Environmental Psychology*, *65*, 101338.

Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. *Ecological monographs*, 81(2), 169-193.

Beeco, J. A., Hallo, J. C., & Brownlee, M. T. (2014). GPS visitor tracking and recreation suitability mapping: Tools for understanding and managing visitor use. *Landscape and Urban Planning*, 127, 136-145.

Bell, F. W. (1997). The economic valuation of saltwater marsh supporting marine recreational fishing in the southeastern United States. *Ecological Economics*, *21*(3), 243-254.

Blotkamp, A., Holmes, N. C., Littlejohn, M., Hollenhorst, S. J. (2011). *Delaware Water Gap National Recreation Area Visitor Study: Summer 2010*. Natural Resource Report NPS/NRSS/SSD/NRR— 2011/620/107705. National Park Service, Fort Collins, Colorado.

Cook, P.S., and Le. Y. (2015). *Cape Lookout National Seashore visitor and resident studies: Fall 2013—Summer 2014*. Park Studies Unit, College of Natural Resources, University of Idaho, Moscow.

Cribbs, T. W., Sharp, R. L., & Brownlee, M. T. (2019). Evaluating the influence of photo order on park visitors' perceptions of crowding at Buffalo National River. *Leisure Sciences*, 1-19.

Cribbs, T. W., Sharp, R. L., Brownlee, M. T., Perry, E. E., & Fefer, J.(2020) In Search of Solitude: A Case Study of Wilderness and Nonwilderness River Users. *International Journal of Wilderness*, 26(3), 72-87

Costanza, R., Pérez-Maqueo, O., Martinez, M. L., Sutton, P., Anderson, S. J., & Mulder, K. (2008). The value of coastal wetlands for hurricane protection. *Ambio*, 241-248.

Daniel, T. C. (1976). *Measuring landscape esthetics: the scenic beauty estimation method* (Vol. 167). Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Epanchin-Niell, R., Kousky, C., Thompson, A., & Walls, M. (2017). Threatened protection: Sea level rise and coastal protected lands of the eastern United States. *Ocean & Coastal Management*, *137*, 118-130.

Food and Agriculture Organization. (2004). CWP handbook of fishery statistical standards. Retrieved from http://www.fao.org/fishery/cwp/handbook/j/en

Freimund, W. A., Vaske, J. J., Donnelly, M. P., & Miller, T. A. (2002). Using video surveys to access dispersed backcountry visitors' norms. *Leisure Sciences*, *24*(3-4), 349-362.

Gedan, K. B., Silliman, B. R., & Bertness, M. D. (2009). Centuries of human-driven change in salt marsh ecosystems. *Annual review of marine science*, *1*, 117-141.

Graefe, A. R., Vaske, J. J., & Kuss, F. R. (1984). Social carrying capacity: An integration and synthesis of twenty years of research. *Leisure Sciences*, 6(4), 395-431

Hallo, J. C., Brownlee, M. T., Hughes, M. D., Fefer, J. P., & Manning, R. E. (2018). The experiential carrying capacity of a barrier island: A norm-based approach at Cumberland Island National Seashore. *Tourism in Marine Environments*, *13*(2-3), 121-140.

Hammitt, W. E., Cole, D. N., & Monz, C. A. (2015). *Wildland recreation: ecology and management*. John Wiley & Sons.

IVUMC. (2016). The interagency visitor use management council. Retrieved from http://visitorusemanagement.nps.gov

Klein, Y.L., and J. Osleeb, 2010. "Determinants of Coastal Tourism: A Case Study of Florida Beach Counties." *J. Coastal Res*., 26 (6), 1149-1156. http://www.jcronline.org/doi/pdf/10.2112%2FJCOASTRES-D-09-00152.1.

Krymkowski, D. H., Manning, R. E., & Valliere, W. A. (2009). Norm crystallization: Measurement and comparative analysis. *Leisure Sciences*, *31*(5), 403-416.

Kulczyk, S., Woźniak, E., & Derek, M. (2018). Landscape, facilities and visitors: An integrated model of recreational ecosystem services. *Ecosystem services*, 31, 491-501.

Little, C., Perry, E., Fefer, J., Brownlee, M., & Sharp, R. (2020). An interdisciplinary review of camera image collection and analysis techniques, with considerations for environmental conservation social science. *Data, 5(2)*, 51 DOI: 10.3390/data5020051

Manni, M. F., Le, Y., and Hollenhorst, S. J. (2013). *Missouri National Recreational River visitor study: Summer 2012.* Natural Resource Report NPS/NRSS/EQD/NRR—2013/645. National Park Service, Fort Collins, Colorado

Manning, R. E. (2022). *Studies in Outdoor Recreation: Search and Research for Satisfaction*. Oregon State University Press, Corvallis

Manning, R. E., & Freimund, W. A. (2004). Use of visual research methods to measure standards of quality for parks and outdoor recreation. *Journal of leisure research*, *36*(4), 557-579.

Manning, R. E., Valliere, W. A., & Wang, B. (1999). Crowding norms: Alternative measurement approaches. *Leisure sciences*, *21*(2), 97-115.

Marion, J. L. (2016). A review and synthesis of recreation ecology research supporting carrying capacity and visitor use management decision making. *Journal of Forestry*, *114*(3), 339-351.

Martin, C. L., Momtaz, S., Jordan, A., & Moltschaniwskyj, N. A. (2015). An assessment of the effectiveness of in-situ signage in multiple-use marine protected areas in providing information to different recreational users. *Marine Policy*, *56*, 78-85.

Merrill, N. H., Atkinson, S. F., Mulvaney, K. K., Mazzotta, M. J., & Bousquin, J. (2020). Using data derived from cellular phone locations to estimate visitation to natural areas: An application to water recreation in New England, USA. *PloS one*, *15*(4), e0231863.

McKercher, B. (1996). Differences between tourism and recreation in parks. *Annals of Tourism Research*, *23*, 563-575.

Needham, M. D., & Rollins, R. B. (2005). Interest group standards for recreation and tourism impacts at ski areas in the summer. *Tourism Management*, *26*(1), 1-13.

Needham, M. D., Szuster, B. W., & Bell, C. M. (2011). Encounter norms, social carrying capacity indicators, and standards of quality at a marine protected area. *Ocean & coastal management*, *54*(8), 633-641.

Newman, P., Marion, J. L., & Cahill, K. (2001, January). Integrating resource, social, and managerial indicators of quality into carrying capacity decision-making. In *The George Wright Forum* (Vol. 18, No. 3, pp. 28-40). George Wright Society.

Peterson, B. A., Brownlee, M. T., Hallo, J. C., Beeco, J. A., White, D. L., Sharp, R. L., & Cribbs, T. W. (2020). Spatiotemporal variables to understand visitor travel patterns: A management-centric approach. *Journal of Outdoor Recreation and Tourism*, 31, 100316.

Ribe, R. G. (1989). The aesthetics of forestry: what has empirical preference research taught us?. *Environmental management*, 13(1), 55-74.

Riungu, G. K., Hallo, J. C., Backman, K. F., Brownlee, M., Beeco, J. A., & Larson, L. R. (2020). Water-based recreation management: a normative approach to reviewing boating thresholds. *Lake and Reservoir Management*, *36*(2), 139-154.

Schiller, J., & Voisard, A. (Eds.). (2004). *Location-based services*. Elsevier.

Shuttleworth, S. (1980). The use of photographs as an environmental presentation medium in landscape studies. *J. Environmental Management*, *11*, 61-76.

South Carolina Department of Natural Resources (2000), *South Carolina Marine Resources Act of 2000,* Section 50-5-15.

Spalding, M. D., Ruffo, S., Lacambra, C., Meliane, I., Hale, L. Z., Shepard, C. C., & Beck, M. W. (2014). The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. *Ocean & Coastal Management*, *90*, 50-57.

Sunger, N., Teske, S. S., Nappier, S., & Haas, C. N. (2012). Recreational use assessment of water-based activities, using time-lapse construction cameras. Journal of Exposure Science & *Environmental Epidemiology*, 22(3), 281-290.

U.S. Census Bureau (2017a.) "*National Intercensal Tables: 2000-2010."* https://www2.census.gov/ programs-surveys/popest/tables/2000-2010/ intercensal/national/us-est00int-01.xls.

U.S. Census Bureau (2017b.) "*U.S. and World Population Clock*." https://www.census.gov/ popclock/.

Vallecillo, S., La Notte, A., Zulian, G., Ferrini, S., & Maes, J. (2019). Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people. *Ecological Modelling*, 392, 196-211.

Vaske, J. J., Beaman, J., Barreto, H., & Shelby, L. B. (2010). An extension and further validation of the potential for conflict index. *Leisure Sciences*, *32*(3), 240-254.

Visitor Use Management Framework: A Guide to Providing Sustainable Outdoor Recreation, Interagency Visitor Use Management Council (IVUMC) (2016). Denver, CO: U.S. Department of the Interior, National Park Servic

CHAPTER 2

Using Location-Based Services (LBS) Data to Identify and Assess Visitor Related Management Actions in a Coastal Protected Area

ABSTRACT

Understanding visitor use has become a major research focus within coastal protected areas (CPAs). Increased visitor use may lead to impacts to the visitor experience and to natural resources. Empirical information and baseline data, collected through rigorous research procedures, is needed to deliberately plan for and manage visitor use to protect coastal natural resources and the quality of visitors' experiences. This study explores the use of location-based services (LBS) data to better understand the capabilities of the technology and to determine if LBS data utility can grow beyond general visitor estimation to answer more detailed management questions. The results of this study found that although LBS data can provide reliable data for high use areas, its ability to address research questions in low use areas is nominal. The outcomes and benefits of this study are to create reliable visitor-based data and results necessary to better understand and manage visitor use. These data are also intended to help inform and guide visitor use management decisions at coastal areas and to allow future monitoring of the area to proactively protect both the visitor experience and key resources.

Key words: *coastal protected areas (CPAs), location-based services data (LBS), visitor use management, visitor estimation*

INTRODUCTION

Coastal protected areas (CPAs) provide for unique recreational opportunities that cannot be found elsewhere. Activities such as boating, fishing, mariculture, visiting estuarine environments, and seeing coastal fauna like nesting shorebirds and sea turtles are all widely popular within CPAs. This use is reassuring since it indicates public support and value for CPAs. However, increased visitor use may lead to impacts to the visitor experience and to natural resources (IVUMC, 2016). Empirical information and baseline data, collected through rigorous social science procedures, is needed to deliberately plan for and manage visitor use to protect the CPA's natural resources and the quality of visitors' experiences.

Recreation and tourism activities have been shown to effect natural resources directly and indirectly through impacts such as soil erosion (e.g., shoreline loss), wildlife disturbance, water pollution, and vegetation loss (Hammitt et al., 2015). Gauging these effects in CPAs is a complex issue. Due to the dynamic nature of these areas, ecological and social impacts are difficult to measure. Open or porous boundaries, and countless access points can make it quite difficult to determine the true number of visitors to these areas and to enforce any management actions being done to prevent or limit visitor's impacts on these natural resources (Hansen, 2016; Merrill et al., 2020; Monz et al., 2019). These open and porous boundaries result in a high degree of visitor dispersion and unpredictability in visitor recreation patterns making it difficult to collect representative samples when counting visitor numbers or determining recreation patterns (Kajala et al., 2007).

These challenges make implementing new, technology-based strategies and techniques like location-based services (LBS) data critical in assessing CPA's ever-changing environments (Hansen, 2016; Kim et al., 2020; Merrill et al., 2020; Monz et al., 2019). LBS data creates digital markers of individual cellphone user's movements through the collection of GPS navigation data and location-based services data during specific app usage. These digital markers can be utilized to represent where visitors have been within CPAs, which allow researchers to look at visitation patterns both spatially and temporally.

Emerging techniques like LBS data may aid in making better and more effective management decisions for CPAs and help assess the success of management actions that limit or restrict visitor access when compared to more traditional methods of data collection (i.e., surveys, on-site observations with field cameras). For example, field cameras offer the advantage of allowing for much more detailed and robust data collection since they are not reliant on a researcher being present at the site but can be limited by their field of view and time-lapse interval setting (Citarella et al., 2019).

Managers often wonder if the management interventions that they implement are effective in addressing the issues they face within their park or protected area (PPA) (Forys et al., 2016; Hockett et al., 2017; Manning, 2022; Martin et al., 2015). To further examine the usefulness of LBS data, this paper investigates whether LBS data can be used to answer more detailed management questions. This study utilizes LBS data approaches to understanding visitor use in the ACE Basin National Estuarine Research Reserve (NERR) in coastal South Carolina (SC). We aim to advance the science of visitor use management in coastal areas by building upon the works done by Merrill et al.

(2020) and Monz et al. (2019) in LBS data utilization in protected areas management and further exploring the versatility of LBS data. By continuing to explore LBS data, we can help protect coastal natural resources and build upon the literature involving new visitor use management (VUM) technologies.

Research Questions

This research plans to build upon previous work done in the fields of remote sensing and CPA management by answering the following research questions:

1. How do LBS methods compare to field camera methods for the determination of visitor use levels across several CPA management areas (i.e., higher-use area, low use backcountry areas, and wildlife habitat area) and over the course of an entire use season?
2. Can LBS data be used to measure outcomes of physical interventions (i.e., symbolic fencing) to manage visitor use in a CPA?
3. Can LBS data be used to measure outcomes of policy interventions (i.e., seasonal restrictions and area closures) to manage visitor use in a CPA?

LITERATURE REVIEW

Challenges facing Coastal Protected Areas

As of 2017, about 94.7 million people, or 29.1% of the total U.S. population, live within the coastal shoreline counties of the lower forty-eight states and as of the most recent census numbers, a 15.3% growth in population has been seen since 2000 in this region (United State Census Bureau, 2019). The National Oceanic and Atmospheric Administration (NOAA) defines coastal shoreline counties as, "… directly adjacent to the

open ocean, major estuaries, and the Great Lakes." (Ache et al., 2015, p. S152). These counties comprise about 10% of the total landmass in the continental U.S. (NOAA, 2019). In the Southeastern United States (e.g., N. Carolina, S. Carolina, Georgia, & Florida), shoreline counties make up 29.3% of the total landmass. Of that 29.3%, only 19.4% of the total land within shoreline counties is protected by either federal, state, or local governments, NGOs, or by private citizens (Epanchin-Niell et al., 2017). Populations in these shoreline counties are expected to continue to rise (Neumann et al., 2015), so further pressure on coastal protected lands could be expected.

Over the past 30 years the population in Colleton County, SC, the county in which the ACE Basin NERR is primarily located, has seen an increase of approximately 38% (United State Census Bureau, 2019). Also, participation in many water-based recreational activities and wildlife watching, which are key activities at the ACE Basin NERR, have increased substantially in society (Outdoor Industry Association, 2020). Because of this growth and the reserve's proximity to the cities of Charleston, SC and Beaufort, SC, the ACE Bain NERR's lands and waterways are being increasingly used for recreation. At the ACE Basin NERR's Botany Bay Wildlife Management Area & Heritage Preserve (WMAHP) alone, visitation has increased to record highs in recent years. Since 2017, total visitation has risen 64.8% from 37,018 visitors to 105,263 visitors annually in 2021. As of August 2022, eleven of the last twenty-four months have seen record numbers of visitation as well. According to the WMAHP's records, during the months of January to July 2021 visitation had already exceeded the previous year's total number of visitors, recording 75,132 visitors to the area. These counts are recorded by analyzing self-check-in data that is mandatory for all vehicles entering the WMAHP.

If these trends in increased population and visitation continue, impacts to the natural resources in these areas will increase. One of the most impacted resources due to increased human activity are critical nesting habitats of shorebirds and sea turtles (Faulhaber et al, 2016; Forys et al., 2016; Koch & Paton, 2013; Lafferty et al, 2006; Long et al., 2022; Monz et al., 2004; Ware & Fuentes, 2020). These anthropogenic impacts come in several forms such as the flushing of birds, ingestion of litter, damage to nests, obstruction to nesting sites, and light pollution. These impacts lead to excess energy expenditures, restricted feeding and foraging, abandoning of nests, and in severe cases, unintended fatalities. CPA managers are constantly faced with the challenge of balancing human use and the conservation of critical coastal habitat.

The Need for LBS Data in Protected Area Management

Currently, CPA managers utilize a variety of data sources to estimate visitor use. Traditional methods of visitation data acquisition consist of collecting entrance fees, parking fees, automated vehicle and pedestrian counters, visitor surveys/ interviews, visitor self-reporting and in-person observational counts (Merrill et al., 2020). Though straightforward, these methods often require significant resources (i.e., time, money, labor) by managers and researchers, and pass a response burden to the visitors that are willing to respond (Manning, 2022). The result of these efforts, however, may contain inconsistent or incomplete results (English & Bowker, 2018; Hansen, 2016; Harada et al., 2011; King & McGregor 2012; Merrill et al., 2020; Monz et al., 2019; Monz et al, 2021). The defuse boundaries of CPAs, consisting of both terrestrial and aquatic entry points, make sampling efforts reliant on formal entry points ineffective. This also makes it increasingly difficult to assess where to conduct in-person observations, establish sites for

effective visitor intercepts, and where to deploy monitoring equipment (Ziesler & Pettebone, 2018).

To overcome some of the limitations of traditional visitor use and estimation methods, researchers have explored data scraping photo-sharing websites and social media posts (Dagan et al., 2020; Keeler et al., 2015; Tenkanen et al., 2017). Although these techniques have been found to give a PPA managers a general sense of spatial and temporal visitor patterns, their main limiting factor is that the data is constricted to only the visitors that participate in social media outlets. These techniques also have trouble accounting for individuals that post long after their visit to a PPA, limited internet connectivity within PPAs, and GPS location estimation used by social media apps with privacy restrictions (Dagan et al., 2020).

The Emergence of LBS Data in Protected Area Management

Over the last few years, PPA researchers have been investigating the utility of LBS data as a means to conduct visitor estimation efforts (Merrill et al., 2020; Monz et al., 2019). Monz et al. (2019) investigated the effectiveness of LBS to determine visitor levels at 22 park units, which included several CPAs, in Orange County, CA. These sites were all considered to be "urban-proximate" by the authors and all residing within the same county that 3.2 million residence called home (Center for Demographic Research, 2019). Monz et al. (2019) purchased data from *StreetLight, Inc*. and utilized their platform *InSight* to analyze LBS data. As stated in the chapter, the authors did "not directly manipulate the raw mobile device [LBS] data but instead relied on the output from the *InSight* model" (Monz et al., 2019, p.8), but they did however use a scaling process to determine vehicle arrivals and use estimates.

The authors used several processes to scale the initial outputs of the *InSight* platform to determine the validity of the data. They utilized annual average daily traffic values reported by local transit authorities to create correlation factors to scale the values derived by *InSight*. Direct daily vehicle counts from an entrance gate of one of the PPAs was also used as a baseline and compared to *InSight* outputs along with counts from areas of known capacities (i.e., full parking lots) and of counts during two fire events where specific units were closed to the public.

The results of this research showed that the use of LBS data was not significantly different when using the baseline correlation factors, where *InSight* underestimated visitation by 5.7% when compared to *in situ* daily vehicle counts (i.e., known capacities or events where a unit was closed to the public). However, the authors suggested further evaluation of LBS data was needed for a proper scaling/calibration technique or procedure.

Merrill et al. (2020) then advanced the work done by Monz et al. (2019) and explored the use of LBS data provided by cellphone users to estimate visitation over a four-month period at more than 500 coastal locations in the New England region of the US. Utilizing aggregated visitor LBS data purchased from *Airsage*, a third-party LBS data provider, Merrill et al. (2020) tested the potential for LBS data collection for visitor estimation at CPAs. This study differed from Monz et al. (2019) "… by incorporating multiple visitation records representing counts of people to a wider set of locations" (p.3, 32-33). Data were calibrated by comparing LBS data to a series of observational counts done at a variety of visitor sites. The calibration data consisted of researcher's onsite observations of visitors at an estuary within the study site, a municipality's visitation

estimates of a local beach, and entrance fees collected at a major municipal beach. Recognizing that these observations may have their own limitations, as previously discussed, they provided cursory data to determine the accuracy of the LBS data.

The results of Merrill et al.'s (2020) study found that the aggregated LBS data overestimated visitation by about four-times. This, however, could be overcome once the data is calibrated by researchers. The three models that Merrill et al. (2020) developed (i.e., Linear, Log-Linear, and Random Forest) were each run to determine the best fit. Researchers found that the Random Forest model, with an R-Squared = 0.91 showed the most promise. After calibration, the authors suggest that LBS data could provide an accurate and consistent way for researchers and managers to estimate visitation in natural areas. It was also found that LBS data had the capability of being predictive of visitor estimation.

Further Applications of LBS Data

Effectiveness of Signage as Means to Reduce Human Intrusions

In a study conducted by Forys et al., (2016), researchers tested the effectiveness of signage as a means for limiting the number of human intrusions into a protected shorebird nesting area on Fort DeSoto Beach, FL. Ten signs were strategically placed around the closed off area, and the area was monitored by video camera to assess the number of intrusions that were occurring. Through the analysis of 400hr of video footage, it was shown that restrictive signage at shorebird nesting areas was highly effective at limiting the number of human intrusions into the nesting area. The study suggests that this method of visitor management could be more effective and practical

compared to the current management practice of hiring bird stewards or depending on volunteers to monitor the area and inform guests of the restricted area.

Building on this trend of finding more practical and efficient ways to manage visitors, it can be argued that the use of LBS data can be used to answer similar questions in a fraction of the time compared to the method previously stated. It is plausible that by selecting certain time parameters in the LBS data, the question of sign effectiveness may be answered without having to go through 400hrs of video data, making this method of testing management intervention effectiveness far more practical and efficient.

Monitoring for Prohibited Camping Practices

Another situation where LBS data can become a useful tool in the management of PPAs is the monitoring of prohibited activities. One specific activity that can be monitored through LBS data is prohibited camping. There is a long-standing tradition of campsite monitoring throughout PPA management (Farrell & Marion, 1998; Goonan et al., 2014; Hammit et al., 2015; Leung & Marion, 1999; Manning, 2022) which includes a varying degree of resources necessary to carry out. LBS data could be utilized to assess the presence of camping both spatially and temporally through the adjustments of several analysis parameters (e.g., visitor presence during the evening, late-night, and early-morning hours) that could indicate an overnight stay. Researchers could then determine if this camping is either occurring in prohibited areas or during prohibited camping seasons.

METHODS

Site Description

The ACE Basin NERR is a nearly 100,000-acre protected estuary located in Beaufort, Colleton, and Charleston Counties in southeast South Carolina (Figure 2.1).

Officially placed under local, state, and federal protection in 1992, the ACE Basin NERR is home to a network of coastal environments including saltwater and brackish-water marshes, maritime forest, and upland pine and bottomland hardwood forests. Due to the number of unique habitats within ACE Basin NERR, the reserve is considered one of the most ecologically diverse locations along the U.S. Atlantic Coast, which according to the reserve creates unique recreational opportunities found in few other public lands and waterways (Maier, 2010).

Areas Geofenced for LBS Analysis

Five areas were used to assess ACE Basin NERR's visitation using LBS data provided by *StreetLight Inc*. These areas were chosen in collaboration with ACE Basin NERR managers and reflect their areas of interest. These areas are also sites where either field cameras were deployed, self-check-in counts were reported, or a combination of both, as another method of visitor estimation, allowing us to use these counts as a proxy for LBS data accuracy and utility. These areas are 1) the Botany Bay WMAHP parking lot (*High-use* area), 2) the Otter, South Fenwick, and Pine Island Complex (*Low-use* areas and overnight primitive camping), and 3) a restricted shorebird nesting area (Figures 2.1 and 2.2).

Deployment of Filed Cameras

Field cameras were deployed to estimate visitation spatially and temporally at 5 locations (Figure 2.1) in the aforementioned areas of the ACE Basin NERR for 12 months. Researchers used a series of *Moltre M-880* game cameras equiped with time-lapse capabilities to collect observational data. These locations, listed above, were identified at a project scoping workshop. The field cameras are commercially purchaced

and used by individuals for recording wildlife activity. These cameras are both reliable and field-tested for the purposes of automatically recording recreation use at a site (Citarella et al, 2019; Cribbs et al., 2019; Hallo and Brownlee, 2013; Little et al., 2020; Peterson et al., 2018; Sharp et al., 2019; Sunger et al., 2012). Field cameras offer the advantage of allowing for much more detailed and robust data collection since they are not reliant on a researcher being present at the site. Also, the cameras have a programmable time-lapse function that allows photos to be taken systematically at specified intervals and during specified hours. The cameras are weatherproof and designed to be easily mounted in natural settings.

Photo points were selected to visually capture the broadest viewshed of the study areas (Figure 2.3). At larger areas or where multiple primary use locations are present at a site, additional photo points were established, and multiple cameras used. At each photo point a camera was placed in a tree, amongst ground vegetation, or otherwise camouflaged to prevent tampering, theft, or vandalism. Where appropriate and feasible, a camera security box, padlock and/or cable lock was used. Cameras were programmed to capture photos every 15 minutes, beginning at 6 a.m. and ending at 10 p.m. Field cameras were deployed for data collection from June 1st, 2021, until May 31st, 2022. These data were broken into monthly segments to capture use levels througout the year. The visitor estimation numbers found through this method will be crucial for cross-validation and scaling of LBS data.

LBS Data Collection

Anonymous LBS data signals were used, along with information gathered from South Carolina Department of Natural Resources (SCDNR), to estimate visitation and

trends. These data were analyzed to understand visitation patterns, including peak use times (e.g., seasonally, monthly, weekly, daily, and in some cases, hourly). These data are publicly available for purchase because most of the U.S. public consent to having phone applications (e.g., weather apps, social media apps, Google Maps) identify their location through 'location services' settings. These location data are often distributed to data clearinghouses for sale through movement analytics services. *StreetLight Data, Inc*. is one such service that obtains mobile device data from two types of locational sources, navigation-GPS data and Location-Based Services (LBS) data. The navigation-GPS data is derived from mobile devices running map-based navigation applications and provides a high degree of spatial precision (3-5m) and frequent location pings. The LBS data is derived from mobile device applications that provided a 5-25m range of spatial precision (Monz, et al, 2019). *StreetLight* data only provides estimated visitation volumes for specifically designated areas and contains no information related to an individual's name, home address, or other identifiable information. It was brought to the attention of the authors that Streetlight Data, Inc. underwent algorithmic and data source changes between April and May of 2022. In order to keep consistent internal validity of our data sample, the authors chose to only conduct 11 months of comparison versus the desired 12-month time frame (StreetLight Data, Inc., 2023a).

Analysis tools are available through *StreetLight InSight*®, an online platform that allows the user to access big data resources and custom data processing software more easily (Streetlight Data, Inc., 2023b). Like Monz et al., (2019), the researchers did not directly manipulate the raw mobile device data but instead relied on the output from the *InSight* model. However, several cross-validation efforts were employed to assess the

accuracy of the LBS data. These efforts consist of 1) self-check-in data from a Botany Bay WMAHP kiosk, 2) utilization of scaling methods found in Monz et al., (2019), 3) days of known visitation (e.g., hunts, guided tours, dates of known camping, prohibited camping season, and weekly closures) and 4) comparisons with the field camera estimations.

Data boundaries for the ACE Basin NERR (i.e., geofence) were established for the locations previously listed (Figure 2.1), and LBS data were gathered within the geofenced areas. Similar approaches have been used recently at Department of Interior sites (Blacketer et al., 2019; Perry et al., 2021).

Analysis for Further Applications of LBS Data

To test the influence of physical management interventions (i.e., symbolic fencing and signage) on visitor behavior, analysis of field camera data and LBS data were conducted to measure visitor intrusion levels within a posted shorebird nesting area. The protected nesting area, located at Botany Bay WMAHP (Figure 2.2), is an 44,154 m^2 area that is traditionally restricted with a symbolic fence made of twisted nylon mason line and thin wooden fenceposts with signs posted on every fencepost (Figure 2.4). On October 13th, 2021, management took down the symbolic fence and signage eliminating any interventions prohibiting visitors from entering the nesting area. To test whether the symbolic fence and signs were an effective management strategy, LBS data were assessed before (June 1st, 2021, until October 12th, 2021) and after management actions (October 13th, 2021, until February 28th, 2022) using means testing to determine if human intrusions increased once the intervention was removed. This sampling period would give researchers roughly 4.5 months of data for each condition.

Similarly, LBS data were analyzed to determine if prohibited camping is happening in the ACE Basin NERR. LBS data were used to identify the presence of camping both spatially and temporally. Based on the presence of data pings during evening, late-night, and early-morning hours, we can indicate the occurrence of an overnight stay. Specifically, data pings from 10pm (at least 1 hour after sunset) until 4am (prior to early morning fishermen) was considered an indication of overnight visitation. In areas where camping is prohibited, researchers looked for the presence of overnight visitors to identify the occurrence of prohibited camping. Overnight visitation was measured during the camping season, November 1st, 2021, through March 31st, 2022, on Otter Island and during the entirety of the sampling period for S. Fenwick Island (Figure 2.5) to validate LBS data with camping permit data. The non-camping season, as defined by ACE Basin NERR management, is from April 1st through October 31st on Otter Island but is only restricted from October 1st – 10th at S. Fenwick Island. LBS data was also analyzed to determine if there is any indication of overnight visitation on Pine Island were all camping is prohibited throughout the year.

Data Calibration and Validation of Vehicle Counts

LBS data was inspected to determine if calibration was necessary and then validated through a series of comparisons with other data collection methods similar to other researchers (Merrill et al. 2020; Monz et al. 2019). The authors chose to recreate similar methods of calibration and validation as Monz et al. (2019) as they too used *StreetLight InSight*® as their primary source of LBS data. To do this, the authors used self-check-in data from Botany Bay WMAHP which was provided by ACE Basin NERR staff. Botany Bay WMAHP was selected as our validation site because of the high

volume of visitation this area receives, and it is also the only site within the ACE Basin NERR that consistently collects daily visitation data that also had a field camera present. Secondarily, Streetlight Data, Inc. notes that its algorithms are more accurate with larger datasets, making this location ideal for use as a calibration site. Taking the data provided by the ACE Basin NERR staff, a monthly average daily traffic (MADT) volume from June 2021 until April 2022 was created.

The MADT volume was then tested against the StreetLight Average Daily Volume (StL) measurement for each month of data collection. Monthly comparisons were chosen because this was the smallest common unit of measurement between the two data collection sampling methods and a unit that would appeal to PPA managers. The StL measurement was provided through the *StreetLight InSight*® platform for the geofenced area around the beach parking lot at Botany Bay WMAHP. Within the platform, StL is categorized by either *Trip Start* or *Trip End.* These numbers differ based on how a trip is generated (refer to Streetlight Data, Inc., 2023a for further explanation). To get to a true StL for a particular month, an average was taken between the *Trip Start* and *Trip End* metrics. The results showed that the averaged StL metric underestimated vehicle counts by anywhere between 5 (3%) to 25 (17%) vehicles depending on the month when compared to the reported self-check-in data for each of the 7 months where an entire MADT dataset was available. With an average difference between MADT and StL of 17 vehicles, a correction factor of 0.144 was created (Table 2.1). In other words, the StL is underestimating MADT for Botany Bay WMAHP by an average of just over 14%. Due to this difference between MADT and StL for vehicle counts, it was decided that the correction factor of 0.144 is necessary for further analysis.

Further validation of the StL metric was conducted by inspecting the number of vehicles detected on Tuesdays during our sampling period. Botany Bay WMAHP is closed to the public every Tuesday throughout the entire year. During these days, we would expect the StL metric for vehicle counts to be relatively low. The reason we do not expect zero vehicles detected is to make sure we account for Botany Bay WMAHP staff that would still be present on the property. On average, there was only 1 vehicle detected on Tuesdays throughout our sampling period, further validating that the vehicle StL metrics generated by the *StreetLight InSight*® platform are relatively accurate.

Data Calibration and Validation of Pedestrian Counts

Similar approaches to calibrate and validate pedestrian data provided by StreetLight were also conducted. Again, self-check-in data from Botany Bay WMAHP was used to create a monthly average daily pedestrian (MADP) volume from June 2021 until April 2022. MADP was then compared to the StL metric for pedestrian traffic by taking the average of *Trip Start* and *Trip End* metrics. The results showed that the averaged StL metric was anywhere between underestimating pedestrian traffic by 40 (27%) individuals or overestimating by 172 (40%) individuals, creating an average correction factor of -0.195 (Table 2.2). Due to this difference between MADP and StL for pedestrian counts, it was decided that the correction factor of -0.195 is necessary for further analysis.

The authors again chose to conduct a "Tuesday Check' to further validate the StL pedestrian metric during our sampling period. During these days, we expected the StL pedestrian metric to be relatively low but still accounting for Botany Bay WMAHP staff that would still be present on the property. On average, there was only 3 individuals

detected on Tuesdays throughout our sampling period, further validating that the pedestrian StL metrics generated by the *StreetLight InSight*® platform are relatively accurate.

RESULTS

Field Camera Data and LBS Data

When analyzing the field camera data, researchers are able to create use estimation numbers by calculating a max '[variable] at one time' (AOT) metric for each month that the cameras were operational. This metric can then be used by managers to monitor any number of variables of concern (e.g., visitors, vehicle, wildlife, dogs, etc.). Due to the nature of the time lapse function on the field cameras, it is difficult to determine if a specific variable is being counted more than once within a time series of photographs. To minimize the amount of double or even triple counting of variables, it is common practice in use estimation studies to utilize the AOT metric to only develop trends and patterns within a dataset (Brownlee et al., 2018; Cribbs et al., 2019; Citerella et al., 2018; Manning, 2022; Sharp et al., 2019). For this study, the average daily max for vehicles at one time (VAOT) and pedestrians at one time (PAOT) per month were utilized to compare field camera data collection and LBS data. This metric was calculated by taking the max AOT for each day within a given month and then taking the average of those numbers. The average daily max AOT per month is the closest metric that can be created using field camera data and be compared to the StreetLight Average Daily Volume (StL). While not one in the same, both AOT and StL are proxies for use and can be justified as comparable metrics of use.

High Use Area- Botany Bay WMAHP

A single field camera was deployed to monitor the amount of use at the beach parking lot for the Botany Bay WMAHP (Figure 2.5). The average daily max VAOT per month was found to be 43. This means that the most vehicles recorded within a single photograph was, on average, 43 throughout the 11 months of data collection. Specific average daily max VAOT results for each month of data collection can be found in Table 2.3.

Similarly, PAOT was counted as well. These results revealed that the average daily max PAOT per month was 12. This means that the most pedestrians recorded within a single photograph was, on average, 12 throughout the 11 months of data collection. Specific average daily max PAOT results for each month of data collection can be found in Table 2.3.

LBS data was also used to assess the amount of visitation that was occurring at Botany Bay WMAHP. StL for both vehicles and pedestrians were calculated using the *StreetLight InSight*® platform. These results found that an average daily volume of 82 vehicles and 367 pedestrians within the geofenced Botany Bay WMAHP parking lot per month during the 11-month data collection period. When vehicle and pedestrian numbers were adjusted using their corresponding correction factors of 0.144 and -0.195, the LBS data found that 93 vehicles and 295 pedestrians, on average daily volume per month, frequented the parking lot during the data collection period. Compared to the on-site counts from ACE Basin staff over the same period, LBS is still underreporting vehicles by an average of 28 (9%) and overestimating pedestrians by 12 (10%).

Low Use Areas- Otter and Pine Islands

A singe field camera was positioned at a popular boat landing and beach at both Otter and Pine Islands during the 11-month data collection period (Figures 2.1 and 2.3). For both islands, we can see that there is a seasonality to visitation with visitation peaking in the summer months and lessening in the winter (Table 2.4). The data collected from the field cameras were analyzed and revealed that an average daily max PAOT per month of 5 pedestrians (i.e., visitors) were spotted by the field cameras at Otter Island on any given day during the 7 months of data collection. On Pine Island, an average daily max PAOT per month of 3 pedestrians (i.e., visitors) were observed by the field camera on any given day during the 11-month data collection. The splits for each month's average daily max PAOT can be seen in Table 2.4. It should be noted that camera malfunctions on Otter Island is why only 7 months of field camera data was collected during the sampling period.

LBS data was also utilized to estimate visitation at both of the *Low use* sites. The *StreetLight InSight*® analysis was run and the results found that the average daily pedestrian (i.e., visitor) use per month for Otter Island was 15 during the 7 months of comparable data collection. At Pine Island, a daily average of 12 pedestrians (i.e., visitors) per month were detected during the 11-month data collection period. When pedestrian numbers were adjusted using the corresponding correction factor of -0.195, the LBS data for the *low use* areas changed to 12 pedestrians for Otter Island and 10 pedestrians for Pine Island.

Effects of Physical Management Interventions - Symbolic Fencing and Signage

The authors wanted to test the capabilities of LBS data to determine if this might be a tool for managers to measure the outcomes of specific management actions. The

first attempt to explore LBS in a specific context was to test whether physical management interventions (i.e., symbolic fencing and signage) influenced visitor behavior. More specifically, did the introduction of symbolic fencing reduce the amount of visitor use on a stretch of beach reserved for shorebird nesting habitat? Table 2.4 compares the findings from both the field camera method and LBS data that was collected. For the field camera method, authors again were able to calculate the average daily max PAOT for each month that the cameras were operational. Both the restricted shorebird nesting area and the surrounding beach, which were both captured by the field camera, were analyzed for use levels. While the symbolic fence was implemented, June 2021- October 12th, 2021, there was an average daily max of 2 PAOT per month within the area of the shorebird nesting site. During this same period, there were only a total of 6 intrusions observed by the field camera and of those intrusions, 5 of them can be identified as being members of the SCDNR sea turtle nesting team. Once the symbolic fence and signs were removed, starting October 13th, 2021, and until February 28th, 2022, there was again, an average daily max PAOT of 2. It should be noted, however, that the field camera in this location malfunctioned on December 19th, 2022, and no further data was collected. The authors still observed a total of 8 'would be' intrusions inside the shorebird nesting area.

The authors then checked the use levels that *StreetLight InSight*® registered. Due to the low use levels that were observed by the field camera, it was decided to run the LBS data analysis for only two time periods, during and after implementation of symbolic fencing, rather than monthly based on the recommendations of the StreetLight Support Team. The team indicated that their algorithms are more likely to be inaccurate

when working with small sample sizes. The results during the implementation of symbolic fencing and signs found that the StL volume for pedestrian (i.e., visitor) use for the area around the shorebird nesting site was 22. Using the correction factor of -0.195, the adjusted StL was calculated to be 18. During this same timeframe, the StL recorded an average daily volume of 1 pedestrian within the restricted shorebird nesting site. Applying the correction factor resulted in the adjusted StL observing less than 1 intrusion while the management action was implemented (Table 2.5). During the period when the symbolic fencing and signs were removed, the *StreetLight InSight*® analysis found 18 StL within the area of the shorebird nesting site while indicating that there would have been an average daily volume of 5 intrusions within the actual shorebird nesting site if restrictions were in place. After adjustment, the StL was reduced to 15 for the entire area and 4 'would be' intrusions on average.

Effects of Policy Interventions – Monitoring Off-Season Camping

The authors also wanted to test the capabilities of LBS data in its effectiveness of detecting possible illegal or off-season camping at primitive, low use camping areas. Due to privacy concerns, field camera data were not collected at any of the 9 primitive campsites within the ACE Basin NERR (Figure 2.5). However, LBS data were compared to camping permit application data that was collected by ACE Basin staff during the months of June 2021 through April 2022 (Table 2.6). Overnight camping was determined by LBS data that were collected between the hours of 10pm and 4am, constituting the possibility of an overnight stay.

Otter Island

During the first part of our sampling period, June 2021-October 2021, camping on Otter Island was restricted. Even though this was the case, *StreetLight InSight*® reported finding a StL of 2 pedestrians (i.e., visitors) during the month of July even though there were no permits given out during this timeframe. From November 2021 through March 2022, ACE Basin NERR staff gave out a total of 18 permits with and average of 5 campers per permit. Even though there was permitted overnight activity on Otter Island during this period, *StreetLight InSight*® reported 0 StL during the targeted time of 10pm to 4am. April 2022 was the beginning of the restricted camping season and both ACE Basin NERR staff and LBS data indicated no overnight stays on Otter Island.

S. Fenwick Island

The same methods were used for determining overnight camping on S. Fenwick Island. On this property, however, camping is allowed all year round except from October 1st through 10th which is the deer hunting season on the island. During the sample period, ACE Basin NERR staff gave out 14 camping permits with an average of 4 campers per permit. During this same period, however, *StreetLight InSight*® reported 0 StL during the targeted time of 10pm to 4am.

Pine Island

Finally, LBS data was assessed for Pine Island. Camping in this location is strictly prohibited throughout the entire year and no permits are given out for overnight camping. *StreetLight InSight*® reported 0 StL during the targeted time of 10pm to 4am.

DISCUSSION

Utilizing LBS Data for Recreation Research

Vehicle Estimation

As it was stated previously, StreetLight Data, Inc. and their support team suggest that their algorithms are most effective when assessing larger sets of data. Botany Bay WMAHP is one of those sites as it received a total of 87,922 visitors during the data sampling period of June 2021 through April 2022. Unfortunately, the vehicle data during this same timeframe was incomplete. Although hunter (i.e., visitor) data was collected during 52 of the 56 days of the hunting season, between September 2021 and December 2021, vehicle data was not collected during this time. Due to these gaps in data, only 7-months were used to create the correction factor for vehicles. It is the opinion of the authors that if vehicle data were to be collected, the observed MADT average during the 4 months where hunting events occurred would be lower due the very restricted access to the property during these events. This influence may have improved our correction factor for vehicles and lowered the amount of overall underestimation seen in the StL data. It is a positive sign, however, that the correction factor for vehicle counts calculated for this research, 0.144, was within 2% points of the one calculated by Monz et al. (2019). Their research used traffic counter data from a nearby Highway Route to calculate their correction factor of 0.158. Although Monz et al. (2019) suggest that calibration efforts may be site specific results of the current study also could be a sign that the technology functions similarly across PPA sites. This finding could also indicate that having a more specific dataset that represents actual use can improve the reliability of the LBS data. The traffic counter data used in Monz et al. (2019) was from a counter that was proximate to the PPA being studied and they were unable to utilize any onsite vehicle counts. This was one benefit that this research has in that the authors were able to use

site specific data in calibration efforts. Although incomplete, it still produced a correction factor similar to the previously stated research. The implications of this finding could mean that this technology may be beneficial even when on-site use data in unavailable for a particular PPA.

It should be noted, however, that even after the correction factor was used, the LBS data still underestimated vehicle use by 9% on average. This is due to the application of an annual correction factor that may not be a perfect fit for all months. One caveat to this finding is that post COVID-19, ACE Basin NERR management changed the location of volunteers at Botany Bay WMAHP. Prior to COVID-19, volunteers were regularly stationed at the kiosk where visitors were to self-check-in at the entrance of the property. Once the property reopened in June 2021, the same time as this project started, volunteers were no longer stationed at the self-check-in kiosk and positioned elsewhere. This change in management strategy may create gaps in data collection due to the lack of oversight and making sure all visitors are properly checking into the property upon entering. This could be why the post-correction difference found in this study, 9%, was higher than the one found in Monz et al. (2019), 5.7%, even though the correction factors were relatively the same. It is promising, however, that the direction of this difference, underestimation, is the same in both studies.

Pedestrian Estimation

One important way that this study differs from Monz et al., (2019) is that it also attempts to calibrate and validate pedestrian counts provided by StreetLight Data, Inc. The access to a robust on-site dataset from Botany Bay WMAHP allowed the researchers to use similar calibration methods as vehicle counts and replicate them for pedestrian

LBS data. Unlike the vehicle counts, the dataset the authors had access to were all but complete except for 4 days of dove hunt events where hunter/visitor data was unavailable at the time of this research. It was interesting that the directionality of pedestrian (i.e., visitor) estimation reversed for pedestrian estimations for the LBS data. The *StreetLight InSight*® platform overestimated these estimates. It is unfortunate that this overestimation was more variable and was close to 20%, but once corrected the difference between on-site counts and the *StreetLight InSight*® was only 10%, nearly the same as vehicle estimation post correction factor calibration. This finding suggests that the end results of the LBS data provided by StreetLight Data, Inc. is consistent in the amount of variance between variable estimates, +/- 9.5%.

Comparing Methods to Answer Specific Management Questions

The goals of this research included comparing data collection technique that are popular in PPA research with the emerging LBS data method. The use of field cameras for the purposes of use estimation has been widespread in the fields of natural resource and visitor management and was discussed earlier in this chapter. Although this method has its positives (e.g., relatively low cost, minimal upkeep, ability to collect data while researchers are not present, etc.) not all environments are created equal. This is especially true in CPAs. Although lovely to recreate in, these environments can be harsh towards monitoring equipment, especially if infrequently checked upon. Salt and sand spray, rising tides, tropical storms and unavoidable sun were all factors that caused some of the research team's monitoring equipment to malfunction. Issues with equipment malfunctioning is not exclusive to CPAs, but these environments in particular create very

unique challenges for researchers bold enough to leave monitoring equipment out in the field for an extended period of time.

Another negative for the field camera method is the way it collects data. Field cameras can collect data in three ways, motion sensed, time lapse, or a combination of both. Both have their advantages and disadvantages but for most VUM research, the time lapse method is common. This method allows for researchers to gather visitor estimates while having control over the time in which photos are take and the specific field of view. This is important if research questions are only concerned with visitor densities in a particular area, general use patterns, or changes in conditions over time, but this method lacks the power to collect true visitation numbers. If a camera takes one photo every 15min, like in the methods of this research and many others, researchers are only capturing a moment in time. Field cameras cannot account for the unknown number of visitors, condition changes, or any other variables that may pass by in between photographs. Such adjustments can be estimated and built into correction calculations but may still not be able to account for abnormal use patterns. The limited field of view also is a point of concern as this severely limits how and where use is monitored. Unless researchers decide to use multiple cameras and collect data on length of stay, it can be near impossible to gauge total use using the field camera method. Also, double counting use with time lapse photos or multiple cameras is an equal concern with field camera data collection methods for estimating visitation.

There are also areas that are not suited for field camera use. Positioning field cameras within the vicinity of established campsites pose privacy concerns and could be construed as an overreach by management who may want to consider the practice. It is

also difficult to determine unknown or illegal campsites without a full survey of possible locations, which would take considerable effort by management that LBS data could overcome.

Study results show that there is a stark difference in the utility of these methods. At sites with higher visitor use, like Botany Bay WMAHP, LBS data was able to get within +/- 9.5% of actual vehicle and pedestrian (i.e., visitor) counts. This alone could be an exciting discovery for PPA managers that are interested in estimating visitation to their sites.

However, at low use sites (i.e., Otter, S. Fenwick, and Pine Islands, and the shorebird nesting beach), the utility of LBS data is questionable. When looking at the results, we can see that there are some large discrepancies between the field camera data and the *StreetLight InSight*® output. There are two ways of looking at this. One way would be to say that the LBS data is overestimating pedestrians far greater than the 9% we see at higher use sites making it unreliable as a method of estimating visitation. Another way is to say that the field camera method is ineffective at picking up the actual use at these sites because it is so dispersed due to its relatively low frequency. When we look at the entire study period, the LBS is indicating that average monthly use is 3x to 9x greater than what could be interpreted by the field camera data. That is why the results from Table 2.6 are so surprising.

When we look at low use areas with a known visitation number (i.e., times and areas with known overnight camping), the LBS data was not able to pick up this use. The only overnight it did indicate was during July 2021 on Otter Island, which surprisingly enough, is during the restricted camping period. These issues revealed by the results of

this study further make the case that LBS data does not perform well in areas with low visitation. *StreetLight's* inability to detect pedestrian traffic at low visitation levels is hampered by the way its data is sourced, aggregated, and normalized. This is unfortunate because the specific management questions that the authors set out to address both involve very specific areas with a finite amount of visitation.

In these cases, it is the authors' suggestion that field camera data collection may be the method of choice when trying to address specific management questions, particularly at low use sites. Field cameras may not be the best tool for determining actual visitation estimates, but they do, however, collect higher resolution information (e.g., weekly, daily, and in some cases, hourly), that at this time, LBS data cannot provide. Field cameras are also able to provide context to use estimates that LBS data cannot provide. In the context of shorebird nesting instructions, the authors would have never been able to identify which intrusions were 'sanctioned' (i.e., intrusions by the SCDNR turtle team) and those by unruly visitors. It is also possible that due to the resolution of the LBS data, 3m - 25m, that the LBS data may register false positives when dealing with narrow boundaries between geofenced areas.

CONCLUSIONS

This research further explores the utility and capability of LBS data in the context of recreation research. Although LBS data may be unreliable and not provide enough data to answer specific management questions at lower use sites, it does show promise in its utility to estimate both vehicle and pedestrian (i.e., visitor) use at higher use sites in PPAs and CPAs alike. Its ability to overcome many of the specific challenges field

monitoring has in CPAs makes LBS data a promising candidate for becoming a more popular method of visitor use data collection in these regions. It is promising that similar correction factors were found for vehicle estimates between two studies researching two very distinct areas. This shows a consistency in the algorithms and data sources used by StreetLight Date, Inc. across spatial and temporal boundaries. This research adds to the growing literature of LBS data utilization by preforming calibrations and validation of the pedestrian StL metrics that *StreetLight InSight*® provides. One limitation to this work, however, is that since this research was conducted, StreetLight Data, Inc. underwent algorithmic and data source changes between April and May 2022. The effects these changes may have for LBS data and its utility for recreation research, both now and in the future, are unknown but further exploration and utilization of LBS data is warranted. As visitation to PPAs evolves, so too, must the tool and techniques used by researchers and managers. These new technologies, like LBS, may open doors to better management practices and provide managers with data that may be unattainable otherwise. It is the authors hope that we, as researchers continue to explore these new technologies and continue to grow the literature on applied techniques in VUM research.

REFERENCES

Ache, B. W., Crossett, K. M., Pacheco, P. A., Adkins, J. E., & Wiley, P. C. (2015). "The coast" is complicated: a model to consistently describe the nation's coastal population. *Estuaries and coasts*, *38*(1), 151-155.

Blacketer, M., Brownlee, M., Sharp, R., Nettles, J., Brunson, M., & Perry, E. (2019). *Visitor use and associated thresholds at Theodore Roosevelt National Park*. Technical report submitted to the U.S. National Park Service. In fulfillment of Cooperative Agreement No. P17AC00126 and S17172.

Brownlee, M.T.J., & Hallo, J. (2013). Motivations to visit designated wilderness at Cumberland Island National Seashore. *The International Journal of Wilderness*, 19(1), 34-40.

Brownlee, M.T.J., Sharp, R.L., Peterson, B.A. & Cribbs, T.W. (2018). Visitor use and associated thresholds at Buffalo National River. Report delivered to management staff at Buffalo National River, Department of Interior, National Park Service. In fulfillment of agreement P16AC00194. Harrison, AR.

Center for Demographic Research. (2019). *Orange Range County facts and figures.* California State University, Fullerton. Retrieved from http://www.fullerton.edu/ cdr/ocff.pdf

Citarella, M.M., Hallo, J.C., Fefer, J.P., Brownlee, M.T.J., Powell, R.B. & Dudley, K.D. (2019) Taking the plunge: Enhancing the visitor experience in waterfall-based state parks *Journal of Park and Recreation Administration*, 37 (3) (2019), pp. 70-88.

Cribbs, T. W., Sharp, R. L., & Brownlee, M. T. (2019). Evaluating the influence of photo order on park visitors' perceptions of crowding at Buffalo National River. *Leisure Sciences*, 1-19.

Dagan, D. T., Sharp, R.L., Brownlee, M.T.J., Wilkins E.J., (2020). Social Media Data in Remote and Low-Use Backcountry Areas: Applications and Limitations. *International Journal of Wilderness,* 26(1)

English, D., & Bowker, J. M. (2018). Introduction to the special issue on visitor monitoring. *Journal of Park and Recreation Administration*, *36*(1).

Epanchin-Niell, R., Kousky, C., Thompson, A., & Walls, M. (2017). Threatened protection: Sea level rise and coastal protected lands of the eastern United States. *Ocean & Coastal Management*, *137*, 118-130.

Farrell, T. & Marion, J. (1998). *An Evaluation of Camping Impacts and Their Management at Isle Royale National Park.* 10.13140/RG.2.2.11336.62725.

Faulhaber, C., Schwarzer, A., Malachowski, K., Rizkalla, C., & Cox, A. (2016). Effects of human disturbance on shorebirds, seabirds, and wading birds: Implications for Critical Wildlife Areas. *Florida Fish and Wildlife Conservation Commission*, Tallahassee, IHR, 3.

Forys, E., Hindsley, P., Miller, M., Wilson, J., Margeson, L., & Margeson, D. (2016). Can Video Cameras Decrease Human Intrusion into a Closed Natural Area? *Natural Areas Journal*. 36. 146-152. 10.3375/043.036.0205.

Goonan, K. C., Monz, C., Bruno, B., & Lewis, T. (2014). *Recreation impact monitoring analysis and protocol development*, Glacier Bay National Park.

Hansen, A. S. (2016). Outdoor recreation monitoring in coastal and marine areas–an overview of Nordic experiences and knowledge. *Geografisk Tidsskrift-Danish Journal of Geography*, *116*(2), 110-122.

Hansen, A. S. (2017). Applying visitor monitoring methods in coastal and marine areas–some learnings and critical reflections from Sweden. *Scandinavian Journal of Hospitality and Tourism*, *17*(3), 279-296.

Hammitt, W. E., Cole, D. N., & Monz, C. A. (2015). *Wildland recreation: ecology and management*. John Wiley & Sons.

Harada, S. Y., Goto, R. S., & Nathanson, A. T. (2011). Analysis of lifeguard-recorded data at Hanauma Bay, Hawaii. *Wilderness & environmental medicine*, *22*(1), 72-76.

Hockett, K. S., Marion, J. L., & Leung, Y. F. (2017). The efficacy of combined educational and site management actions in reducing off-trail hiking in an urban-proximate protected area. *Journal of environmental management*, *203*, 17-28.

Interagency Visitor Use Management Council (IVUMC). (2016). *IVUMC-VUM Framework*. Retrieved from http://Visitorusemanagement.nps.gov.

Kajala, L., Almik, A., Dahl, R., Dikšaitė, L, Erkkonen, J., Fredman, P., … Wallsten, P. (2007). Visitor monitoring in nature areas – a manual based on experiences from the Nordic and Baltic countries (207 p*). TemaNord* 2007:534. Stockholm: Naturvårdsverket.

Keeler BL, Wood SA, Polasky S, Kling C, Filstrup CT, Downing JA (2015). Recreational demand for clean water: evidence from geotagged photographs by visitors to lakes. *Frontiers in Ecology and the Environment*. 13(2):76–81.

Kim, Y. J., Lee, D. K., & Kim, C. K. (2020). Spatial tradeoff between biodiversity and nature-based tourism: Considering Mobile Phone-Driven Visitation Pattern. *Global Ecology and Conservation*, 21, e00899.

King, P., & McGregor, A. (2012). Who's counting: an analysis of beach attendance estimates and methodologies in southern California. *Ocean & coastal management*, *58*, 17-25.

Koch, S. L., & Paton, P. W. (2014). Assessing anthropogenic disturbances to develop buffer zones for shorebirds using a stopover site. *The Journal of Wildlife Management*, 78(1), 58-67.

Lafferty, K. D., Goodman, D., & Sandoval, C. P. (2006). Restoration of breeding by snowy plovers following protection from disturbance. *Biodiversity & Conservation*, 15(7), 2217-2230.

Leung, Y. F., & Marion, J. L. (1999). Characterizing backcountry camping impacts in Great Smoky Mountains national park, USA. *Journal of Environmental Management*, *57*(3), 193-203.

Little, C., Perry, E., Fefer, J., Brownlee, M., & Sharp, R. (2020). An interdisciplinary review of camera image collection and analysis techniques, with considerations for environmental conservation social science. *Data, 5(2),* 51 DOI: 10.3390/data5020051

Long, T. M., Eldridge, J., Hancock, J., Hirama, S., Kiltie, R., Koperski, M., & Trindell, R. N. (2022). Balancing human and sea turtle safety: Evaluating long-wavelength streetlights as a coastal roadway management tool. *Coastal Management*, 50(2), 184-196.

Maier, P. (2010). Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve Management Plan 2011-2016. *South Carolina Department of Natural Resources, Charleston, SC*.

Martin, C. L., Momtaz, S., Jordan, A., & Moltschaniwskyj, N. A. (2015). An assessment of the effectiveness of in-situ signage in multiple-use marine protected areas in providing information to different recreational users. *Marine Policy*, *56*, 78-85.

Manning, R. (2022) *Studies in outdoor recreation: search and research for satisfaction.* Oregon State University Press, Corvallis

Merrill, N. H., Atkinson, S. F., Mulvaney, K. K., Mazzotta, M. J., & Bousquin, J. (2020). Using data derived from cellular phone locations to estimate visitation to natural areas: An application to water recreation in New England, USA. *PloS one*, *15*(4), e0231863.

Monz, C. A., Young, E. A., & Leung, Y. F. (2005). *Monitoring the impacts of visitors to shorebird populations in the NPS coastal and barrier island network areas*. In Proceedings of the 2004 Northeastern Recreation Research Symposium; Lake George, NTK Bricker, ed. General Technical Report NE-326. Newtown Square, Pa.: US Department of Agriculture-Forest Service, Northeastern Research Station (pp. 373-377).

Monz, C., Creany, N., Nesbitt, J., & Mitrovich, M. (2021). Mobile Device Data Analysis to Determine the Demographics of Park Visitors. *Journal of Park & Recreation Administration*, *39*(1).

Monz, C., Mitrovich, M., D'Antonio, A., & Sisneros-Kidd, A. (2019). Using mobile device data to estimate visitation in Parks and protected areas: an example from the nature reserve of Orange County, California. *Journal of Park Recreation and Administration*, *37*(4), 92-109.

National Oceanic and Atmospheric Administration (2019). What percentage of the American population lives near the coast? *NOAA's National Ocean Service*. https://oceanservice.noaa.gov/facts/population.html.

Neumann, B., Vafeidis, A. T., Zimmermann, J., & Nicholls, R. J. (2015). Future coastal population growth and exposure to sea-level rise and coastal flooding-a global assessment. *PloS one*, *10*(3), e0118571.

Outdoor Industry Association. (2020) *2020 Outdoor Participation Report*. https://outdoorindustry.org/resource/2020-outdoor-participation-report/.

Perry, E., Powell, B., Brownlee, M., & Sharp, R. (2021). *Visitor use within and across seasons at Joshua Tree National Park.* Technical report submitted to the U.S. National Park Service. In fulfillment of Cooperative Agreement No. P18AC01217.

Peterson, B., Brownlee, M., Sharp, R., & Cribbs (2018). *Visitor Use and Associated Thresholds at Buffalo National River*. Technical report submitted to the U.S. National Park Service. In fulfillment of Cooperative Agreement No. P16AC00194.

Sharp, R.L., Brunson, M.A., Reigner, N., & Cribbs, T.W. (2019). *Visitor use management planning in the rim to rim corridor at Grand Canyon National Park.* Report delivered to management staff at Grand Canyon National Park, Department of Interior, National Park Service.

Streetlight Data, Inc. (2023a) *StreetLight* All Vehicles Data Updates – December 2022. Last Updated 5/2023. Retrieved from https://support.streetlightdata.com/hc/en-us/articles/10397273102363-All-Vehicles-Data-Updates-December-2022?source=search

Streetlight Data, Inc. (2023b) *StreetLight* Methodology and validation studies. Retrieved from https://www.streetlightdata.com/whitepapers/

Sunger, N., Teske, S. S., Nappier, S., & Haas, C. N. (2012). Recreational use assessment of water-based activities, using time-lapse construction cameras. *Journal of Exposure Science & Environmental Epidemiology*, 22(3), 281-290.

Tenkanen H, Di Minin E, Heikinheimo V, Hausmann A, Herbst M, Kajala L. (2017). Instagram, Flickr, or Twitter: Assessing the usability of social media data for visitor monitoring in protected areas. *Scientific Reports*. 7(1):17615. https://doi.org/10.1038/s41598-017-18007-4 PMID: 29242619

United States Census Bureau (2019). *About 60.2m live in areas most vulnerable to hurricanes.* Census.gov. Retrieved April 5, 2022, from https://www.census.gov/library/stories/2019/07/millions-of-americans-live-coastline-regions.html

Ware, M., & Fuentes, M. M. (2020). Leave No Trace ordinances for coastal species management: influences on sea turtle nesting success. *Endangered Species Research*, 41, 197-207.

Ziesler, P. S., & Pettebone, D. (2018). Counting on visitors: A review of methods and applications for the National Park Service's visitor use statistics program. *Journal of Park and Recreation Administration*, 36(1)

TABLES AND FIGURES

Table 2. 1: Comparisons of vehicle counts between Visitor Self-Check-In Monthly Average Daily Traffic (MADT) volume and StreetLight Average Daily Traffic Volume (StL) metric for Botany Bay WMAHP

	Data Collection Period											
	June 2021	July 2021	August 2021	September 2021	October 2021	November 2021	December 2021	January 2022	February 2022	March 2022	April 2022	Mean**
MADT	147	157	126	162*	138*	79*	100*	61	91	122	148	122
StL	122	135	115	52	49	26	48	44	68	102	143	104
MADT - StL	25	22	7	-	-	-	-	17	23	20	5	17
Correction Factor	0.17	0.15	0.05	-	-	-	-	0.28	0.25	0.16	0.03	0.144
* Months containing partial vehicle data due to hunting events (Only number of hunters was recorded during hunting events) ** Means for the 7 complete months of data												

Table 2. 2: Comparisons of visitor counts between Visitor Self-Check-In Monthly Average Daily Pedestrians (MADP) volume and StreetLight Average Daily Pedestrian Volume (StL) metric for Botany Bay WMAHP

	Data Collection Period											
	June 2021	July 2021	August 2021	September 2021	October 2021	November 2021	December 2021	January 2022	February 2022	March 2022	April 2022	Mean
MADT	478	544	390	222*	210*	148*	180*	177	256	341	436	305
StL	582	676	493	212	213	108	258	178	268	444	608	367
MADT - StL	-104	-132	-103	10	-3	40	-78	-1	-12	-103	-172	-60
Correction Factor	-0.22	-0.24	-0.26	0.04	-0.01	.27	-0.43	< -0.01	-0.05	-0.3	-0.39	-0.195
*Months containing partial pedestrian data due to hunting events (Data for 4 day-long dove hunting events were missing)												

Table 2. 3: Comparisons between field camera average daily max at one time (AOT) per month and StreetLight Average Daily Volume (StL) metrics for both vehicles and pedestrians at Botany Bay WMAHP

Month	Average Daily Max VAOT	Vehicle StL	Average Daily Max PAOT	Pedestrian StL
June 2021	28	122	9	582
July 2021	29	135	9	676
August 2021	25	115	7	493
September 2021	16	52	5	212
October 2021	14	49	3	213
November 2021	12*	26	4*	108
December 2021	34*	48	6*	258
January 2022	14	44	4	178
February 2022	19	68	5	268
March 2022	25	102	6	444
April 2022	30	145	7	608
Mean (After Correction Factor)	22	82 (93)	6	367 (295)
* Incomplete data due to camera malfunction				

Table 2. 4: Comparisons between field camera average daily max pedestrians at one time (PAOT) per month and StreetLight Average Daily Volume (StL) metrics for pedestrians at monitored *low use* sites

	Otter Island		Pine Island	
Month	Average Daily Max PAOT	Pedestrian StL	Average Daily Max PAOT	Pedestrian StL
June 2021	6	12	7	21
July 2021	15	57	11	59
August 2021	4	31	7	26
September 2021	5	24	4	10
October 2021	3	10	2	5
November 2021	2	3	<1	0
December 2021	1	3	1	0
January 2022	*	0	<1	0
February 2022	*	0	<1	0
March 2022	*	8	1	0
April 2022	*	22	3	7
Mean (After Correction Factor)	5	15 (12)	3	12 (10)
* Incomplete data due to camera malfunction				

Table 2. 5: Number of pedestrians (visitors) observed before and after symbolic fence was implemented around shorebird nesting area at Botany Bay WMAHP

		Field Camera		LBS	
	Month	Average Max PAOT	Total Intrusions (Turtle Team)	Entire Area StL (After Correction Factor)	Intrusions StL (After Correction Factor)
With Symbolic Fence	June 2021	3	0 (0)	22 (18)	1 (<1)
	July 2021	4	2 (0)		
	August 2021	2	3 (2)		
	September 2021	2	2 (2)		
	October 1st -12th 2021	1	1 (1)		
Without Symbolic Fence	October 13th-31st 2021	2	1 (0)	18 (15)	5 (4)
	November 2021	1	7 (0)		
	December 1st – 19th 2021	2	0 (0)		
	December 20th – 31st 2021	*	*		
	January 2022	*	*		
	February 2022	*	*		
* Incomplete data due to camera malfunction					

Table 2. 6: Average number of overnight campers from permits and StreetLight Average Daily Volume (StL) for pedestrians (visitors) during June 2021 through April 2022 for Otter, S. Fenwick, and Pine Islands

		Otter Island		S. Fenwick Island			Pine Island	
	Month	Average # of Campers	StL from 10pm to 4am	Camping Season (Restricted during October 1st -10th)	Average # of Campers	StL from 10pm to 4am	All Camping Restricted on Entire Property	StL from 10pm to 4am
Restricted Camping	June 2021	0	0		6	0		0
	July 2021	0	2		2	0		0
	August 2021	0	0		0	0		0
	September 2021	0	0		0	0		0
	October 2021	0	0		2	0		0
Camping Season	November 2021	5	0		5	0		0
	December 2021	4	0		5	0		0
	January 2022	0	0		3	0		0
	February 2022	5	0		6	0		0
	March 2022	0	0		4	0		0
Restricted Camping	April 2022	0	0		5	0		0

Figure 2. 1: Map of ACE Basin NERR

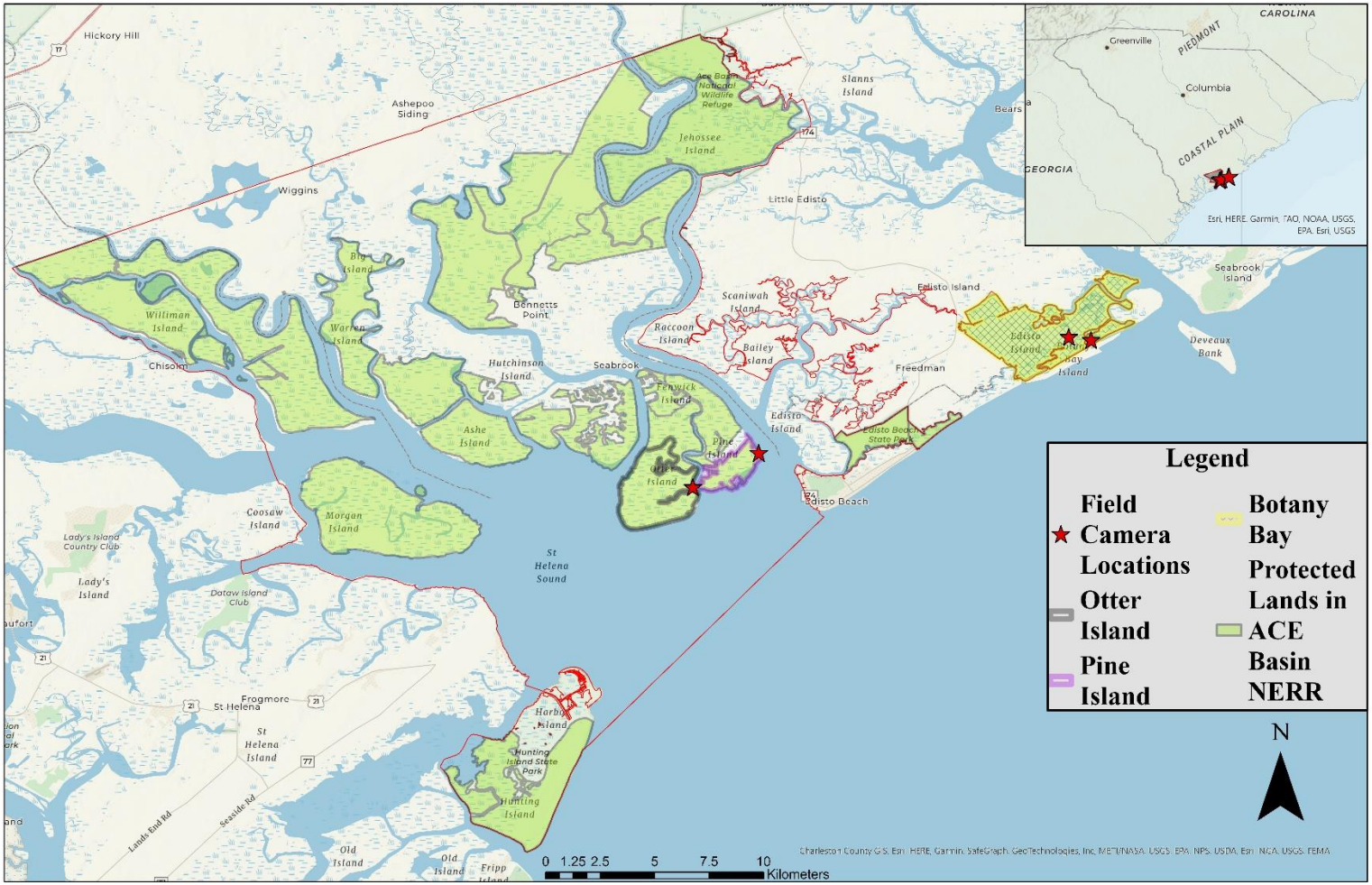
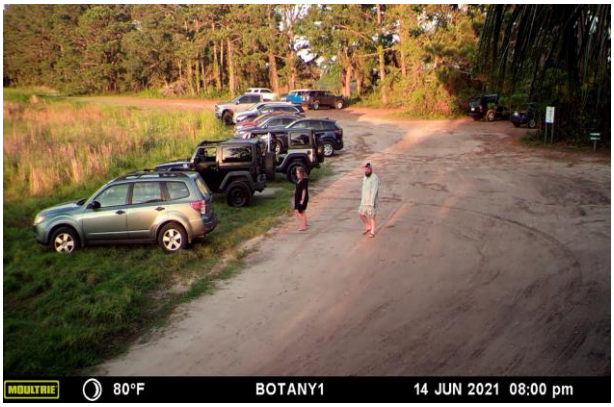


Figure 2. 2: Map of Botany Bay WMAHP and protected shorebird nesting habitat.

Figure 2. 3: Viewshed of field cameras on location



Botany Bay Plantation Wildlife Management & Area Heritage Preserve - Parking Lot

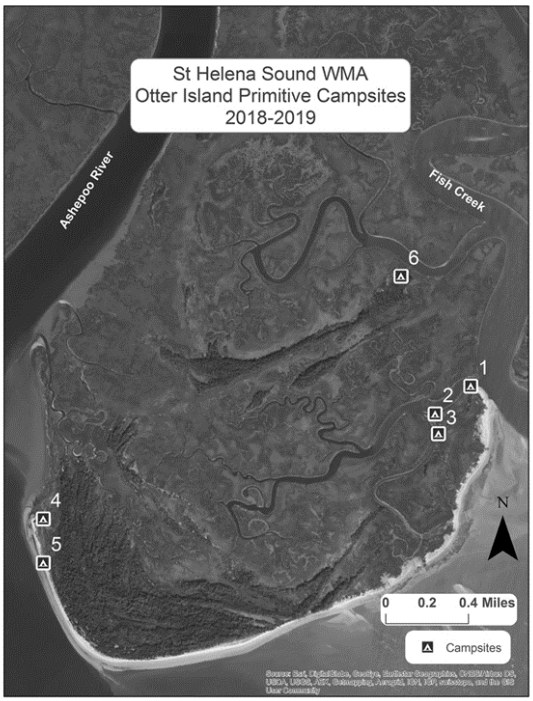
Botany Bay Plantation Wildlife Management & Area Heritage Preserve - Bird Nesting Area

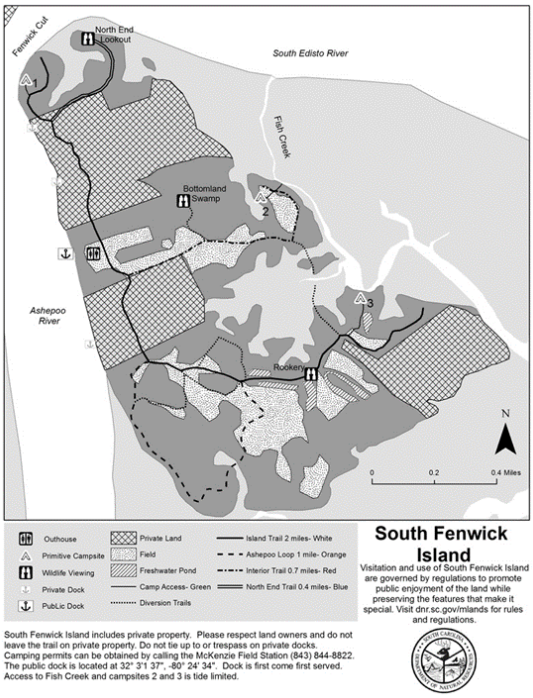
Otter Island- North Side

Pine Island – S. Edisto River

Figure 2. 4: Photograph of symbolic fencing and posted signage at shorebird nesting habitat at Botany Bay WMAHP (taken 8/10/2022)

Figure 2. 5: Map of Otter Island and S. Fenwick Island primitive campsites (Provided by ACE Basin NERR management)





CHAPTER 3

Social Carrying Capacity of Oyster Mariculture on Coast of South Carolina: Understanding Stakeholders Perceptions and Thresholds for Oyster Mariculture Development

ABSTRACT

The demand and willingness to pay a higher price for farmed shellfish has increased among consumers and chefs, especially in coastal tourism destinations like those in South Carolina. There is a growing embrace of oysters as a local food and quality niche product, and considerable growth potential exists for oyster farming in SC. However, it is unknown if the coastal stakeholders will support oyster mariculture's (i.e., farming) growth and the extent or type of farm that could occur without opposition. This study examines the social carrying capacity for oyster farming in Charleston and Beaufort Counties, SC. A survey of 383 stakeholders in the study counties was conducted to 1) identify thresholds for specific indicators, such as the size of oyster farms and 2) to determine the societal acceptability of potential actions or policies that may be used in the permitting and management of oyster farms. This survey used photographic simulations of oyster farms, including virtual reality (VR) 360° still images and videos, to elicit responses from participants. The goal of this research was to develop and deliver information on the social carrying capacity of oyster farming in ways that create utility to permitting agencies, extension services, shellfish growers, and other organizations that work directly with oyster farmers. The results show that *Lack of Knowledge* is the biggest hurdle in fully assessing the public's acceptability of oyster mariculture and that consistent and scientifically factual information about oyster mariculture needs to be more readily available to the public. The authors also discuss the efficacy of the use of VR technologies for the purposes of conducting normative threshold research that utilizes visual based methods.

Key words: *virtual reality (VR), mariculture, social carrying capacity, social acceptability, visual-based methods*

INTRODUCTION

Shellfish mariculture (i.e., farming in saltwater environments) presents multiple economic and entrepreneurial opportunities for coastal regions. As a result of the promotion of local seafood, along with the growing familiarity with shellfish products such as oysters and clams, the demand and willingness to pay a higher price for farmed shellfish has increased among consumers and chefs, especially in coastal tourism destinations (Kecinski et al., 2017). This study investigated social acceptance, constraints, barriers, and hurdles to oyster mariculture in South Carolina (SC). Specifically, it targeted assessments of stakeholder perceptions with regard to social acceptability towards the expansion of oyster mariculture and associated infrastructure in Beaufort and Charleston counties. It gathered these perceptions from a broad range of stakeholders – including coastal homeowners, tourists, recreational boaters, and recreational anglers/shellfishers – who are the most likely to encounter oyster farming infrastructure and may support or oppose its expansion.

Landowners, other coastal residents, and tourists may have other valid interests in the same waters that are best suited for mariculture. Specifically, a personal or business conflict of interest in how the water is used could also influence their acceptance of increased shellfish mariculture. Because oyster farms are leased in public waters, there may be opposition towards an increase in mariculture if it is perceived to only benefit the growers who are able to use a public resource for private gain or become an impediment to the coastal viewshed. Consequently, oyster mariculture expansion should be strategic with regard to how it effects navigation, coastal appearance, and utilizes the shared resources and space of coastal areas with other diverse marine dependent industries and

recreational activities. It is important to explore potential conflicts in activity or values of the nearshore area that threaten acceptability of oyster mariculture expansion and that could be ameliorated through planning, policy, zoning strategies, or permits.

There is a growing embrace of oysters as a localized food source and reflection of maritime culture outside of the traditional Northeast coastal region, with many seeing the Southeast as the future 'Napa Valley of Oysters' (Graff, 2011; Jacobsen, 2016; Neimark, 2016). Leveraging this interest in local foods, entrepreneurial shellfish farmers are also beginning to successfully promote and sell shellfish to niche markets, allowing for an even broader economic impact of this industry to surrounding communities. Market demand has been increasing across the U.S. for premium single oysters that are branded according to the waters in which they are grown (Kecinski et al., 2017); for example, in SC, Lady's Island "Single Lady" Oysters have been featured in Southern Living magazine and on National Public Radio (NPR). Since single oyster production from wild harvest has dwindled in the state, SC Sea Grant has noted that farming oysters is considered the best strategy for capitalizing on market trends. In another recent story on NPR, Deborah Elliott (2017) discusses the opportunities for families and entrepreneurs on the Alabama coast who are turning to oyster farming to complement the traditional harvesting of Gulf of Mexico wild oysters.

Considerable growth potential exists in SC for oyster mariculture development. Within one of the NPR reports, SC oyster grower Frank Roberts noted that, "The demand [for oysters] is incredible. I can't keep up with it. We are growing 2 million oysters a year right now and selling every last one" (Neimark, 2016, para. 11). As such, the expansion of oyster farming presents a valuable opportunity to create and retain jobs in coastal areas

of SC while also providing critical ecosystem services (e.g., improved water quality) to benefit important nursery habitats (Filgueira et al., 2015). Putting this in terms of economic value, Virginia – a state that was an early adopter of oyster farming on the East Coast – sold $17.1 million in oysters in 2014 (Hudson & Murry, 2015). In comparison, SC oyster mariculture production was valued at $135,547 in 2016, with growth to $3,725,107 in 2019 (ACCSP.org). The current industry makeup, as of April 2021, South Carolina Department of Natural Resources (SCDNR) reports that there are currently 36 mariculture permits being utilized with one in the permitting process. Much of the existing mariculture in SC are oyster farms; 17 of the 36 permits are oysters only, four are both clam and oyster, and fifteen are clams only. SCDNR also reports that 26 of the permits are currently using bottom cages while the remaining 10 permits are for water column or floating cages. In total, 976.4 acres of SC intercoastal waterways were being utilized for mariculture practices. There is currently no limit on the number of SC oyster mariculture permits available, and an online tool provided by SCDNR shows ample areas for mariculture expansion (S.C. Sea Grant Consortium, 2023a).

In this chapter, a survey of coastal area stakeholders will be discussed which included a component utilizing simulated VR/360° photographs captured at typical sites that are suitable for oyster mariculture development. Specifically, the imagery was manipulated to accommodate the variables to be measured in the survey which highlight the possibility of the visual impacts of oyster mariculture, as described above. This visual approach to measuring social carrying capacity represents a range of development levels and conditions (e.g., oyster farm size and distributions of equipment). Additionally, the survey included questions that 1) assess perceptions of how industry growth may threaten

perceived or real access to waterway activities, 2) evaluate attitudes towards proximity to oyster mariculture, 3) quantify and measure the importance of social values attached to the waterfront landscape, and 4) measure values, beliefs, and knowledge (both subjective and objective knowledge) towards aquaculture and oyster mariculture.

The results of this study are intended to assist with SCDNR's efforts to create tools and permitting processes by identifying and regulating acceptable levels of future oyster mariculture growth based on specific attributes influencing societal acceptability and social values. This represents the social carrying capacity of oyster mariculture, or the public's capacity to accept oyster farming (i.e., the size of farm, arrangement of farm, and distance from farm), at different levels of development. Overall, this study provides information and tools – based on public input from a broad array of coastal waterway users – to assist coastal managers, communities, and oyster farmers with identifying socially acceptable limits of mariculture development in these areas using traditional and new visual based methods.

LITERATURE REVIEW

Challenges Facing Oyster Mariculture Expansion

The potential for expansion of oyster farming may be at risk of increased opposition from various waterway stakeholders. The current shellfish leasing application and culture permit process requires oyster farmers to open site selection for public comment and communicate with property owners adjacent to the proposed culture area. As such, those who are working to expand or invest in oyster mariculture have encountered landowner concerns that mariculture and related infrastructure detract from the aesthetic appeal and perceived accessibility to coastal waters (e.g., social carrying

capacity; Dalton et al., 2017). Beyond the concern from coastal landowners, other stakeholder perspectives must also be considered including waterway users such as terrestrial and water-based tourists, recreational boaters, and recreational anglers and shellfishers (Chu et al., 2010). This approach assures that overlapping or conflicting uses and values are fully reflected in social acceptability analysis.

The complex social reasoning for the support or opposition to mariculture expansion needs to be unpacked to better understand the most important variables influencing these perceptions. For example, on the U.S. West Coast, considerable conflict arose over Pacific geoduck clam aquaculture in the Washington state tidelands. In that case, Rudell (2012) identified two divergent social perspectives: those who were favorable about the potential growth of geoduck mariculture (i.e., managers, academic scientists, shellfish growers, tribal members, and students), and those who were against further development of geoduck culture (i.e., waterfront landowners and non-governmental organizations). Areas of disagreement in this case included who benefits from aquaculture development, ecological impacts on local habitats, contribution to water quality restoration, and conversion of recreational beaches and tidelands into feedlots. In the Nelson/Marlborough region of New Zealand (NZ) expansion of both aquaculture and tourism in the coastal zone was rapid, and infrastructure (i.e., multiple patches of black buoys) was highly visible, leading to a moratorium on aquaculture for several years (Jodice et al., 2009). Researchers found that some tourism business leaders and residents not connected to the NZ seafood industry in the region believed that nearshore mussel farms were unattractive, created impediments to recreational boating, and were negatively impacting the marine ecosystem.

Low support for aquaculture may also be attributed to lack of knowledge about marine farming and the need for continued outreach (Jodice et al., 2015). Jodice et al. (2015) examined baseline support at the current level of mariculture development in South Carolina. The results indicated that among tourist and residents in Charleston and Beaufort counties in SC, there was moderate support for mariculture and a positive relationship between self-assessed knowledge about mariculture and support. However, 37% of residents were not aware that mariculture was even occurring. Interviews conducted with seafood industry and tourism stakeholders within the same study also indicated a relatively low perceived level of conflict between mariculture activities and other waterway users. Nevertheless, interview results also suggested there is a strong concern that the "not in my backyard" (NIMBY) perspective could become more problematic with expansion of mariculture, especially for oyster farming (Brownlee et al., 2015; Duffy et al., 2016).

Social Carrying Capacity & Photo Simulation

Limited research exists on social carrying capacity of shellfish mariculture with the notable exception of Dalton et al. (2017) who used photo simulation to determine acceptability of oyster farming in salt ponds off Rhode Island. Social carrying capacity is defined as the level of use beyond which environmental and social impacts exceed acceptable levels of an evaluative standard (Graefe, et al., 1984; Manning, 2013). The 18 simulated photos used in their study were broken up into two sets of 9 with differing background settings. Each set also depicted an increasing level of aquaculture development. The photo series were then presented to participants in a random order and participants were asked to rate their acceptability on a 7-point scale where 1= Very

Unacceptable and 7=Very Acceptable. Photo simulations are a common tool in developing indicators (i.e., variables used to measure and manage an area) and thresholds (i.e., minimal acceptable conditions) that relate to social carrying capacity (Altman, 1975; Anderson, 1984; Cribbs et al., 2019; Manning & Valliere, 2001; Nielsen & Shelby, 1977; Shelby et al., 1989; Vaske & Shelby, 2008). Dalton et al.'s (2017) study provides cursory evidence that social carrying capacity must be investigated further. Opposition from coastal waterway stakeholders and users may be due to a few social factors that are rooted in differing attitudes, values, goals, or knowledge regarding oyster mariculture. The study revealed moderate support for shellfish aquaculture but a significant decline in acceptability by wild-harvest fishermen and residents when there was a small addition of aquaculture infrastructure.

Response to Dalton 2017

Guided by the work done by Dalton et al. (2017), this research applied the concept and methods of social carrying capacity. Similar to Dalton et al. (2017), this study also examined the amount, type, and locations of oyster mariculture that are acceptable from the perception of multiple stakeholders and users of coastal waterways by using photo simulation as our primary tool. However, some aspects of this study differ from the one done by Dalton et al. (2017). First, researchers in this study chose not to present photographs in random order but in a sequential progression. This decision was based on previous work done by Cribbs et.al. (2019) which showed that photo order has limited to no significant effect on visitors' normative thresholds and associated norms. Second, researchers chose to include emerging forms of photo simulation (i.e., virtual reality (VR) and 360° imagery) to determine what issues and advantages there are for survey

respondents and researchers in using VR/360° imagery to measure social norms in a field-based setting. It is thought that two-dimensional (2D) photos may only have the ability to portray limited sensory information which may create difficulties when developing accurate indicators and thresholds (Blascovich et al., 2002; Smith, 2015). The development of new techniques such as VR/360° imagery may help researchers better recreate life-like scenarios that are otherwise impossible to express to survey participants. This technique can be applied to social carrying capacity studies (Fisher-Gewirtzman, 2018; Wang et al., 2020), which has opened the door to exploring these new technologies when attempting to assess stakeholder acceptability and social carrying capacity.

The Use of Virtual Reality in Social Sciences

As stated earlier, photo simulations are a common tool in social science to develop thresholds for a variety of indicators (Altman, 1975; Anderson, 1984; Brown et al., 1989; Cribbs et al., 2019; Manning & Valliere, 2001; Nielsen & Shelby, 1977; Shelby et al., 1989; Vaske & Shelby, 2008) with 2D photographs have become the most used method to portray environmental and social conditions for which acceptability can be measured (Manning & Freimund, 2004). However, in recent years, advancements in computer imaging technology have raised the question of whether there is a more effective way to convey information to survey participants.

It is hypothesized that 2D photos may only have the ability to portray limited sensory information which may create difficulties when developing accurate indicators and thresholds. This idea has opened the door to exploring these technologies when attempting to assess stakeholder acceptability and social carrying capacity.

As Wang et al. (2020) explains, VR refers to the experience of presence through technological means. More specifically, VR experiences are expressed using head-mounted displays (HMD) or VR headsets. These headsets then display a virtual environment (VE) that is expressed through an immersive system called immersive virtual reality (IVR). These VE's can be created digitally through sophisticated modeling software or by compiling a series of 2D photographs taken from a particular site, then rendered and displayed as 3D images within the IVR. Although this is an emerging technology, there have been a number of studies in the last decade that have suggested that IVR holds validity as a technique to display ecological information (Armougum et al. 2019; Browning et al., 2021; Gupta et al. 2017; Heydarian et al. 2015; Iachini et al. 2016; Kronqvist et al. 2016; Rossetti and Hurtubia 2020; Yu et al. 2018). Even with all the recent research being done exploring the capabilities of IVR, Wang et al. (2020) seems to be one of the only studies applying this technique to social acceptability (e.g., perceptions of crowding).

In 2020, Wang et al. explored the capabilities of IVR in comparison to other, more traditional methods (i.e., 2D photographs, on-site experiences, and on-site photos) to measure perceptions of crowding. The results from Wang et al. (2020) provide possibly the first successful test of validity of IVR in perceived crowding-related research. This study demonstrated that not only were participants more sensitive to crowding when being exposed to IVR when compared to 2D photos, the study also found that there was no significant difference between IVR and on-site experiences. Simply put, IVR was able to express the on-site crowding experience more effectively than the traditional method of displaying 2D photos. 2D photographs can only portray limited

sensory information and this difference may prove critical to understanding visitors' perceptions of use and developing thresholds.

Research Questions

While the bulk of this study is focused on determining the social carrying capacity of oyster mariculture expansion, there is empirical research that provides support for the potential use of IVR in measuring stakeholder perceptions. There is also a large gap in the literature investigating the application of such techniques outside of controlled laboratory environments. Consequently, this study aimed to answer the following research questions.

1. What are stakeholders' perceptions of oyster maricultural development, and related issues and benefits, in coastal South Carolina waterways?
2. What are the norm-based thresholds for viewing oyster mariculture operations from different distances, of different sizes, arrangements, and in varying contexts (i.e., viewed from a dock or within view of a major transportation bridge)?
3. What issues and advantages emerge for survey respondents and researchers in using VR/360° imagery to measure social norms in a field-based setting?

METHODS

Site Description

To investigate these questions, we conducted this study in communities and waterfronts near areas open to mariculture permitting. This includes sampling a public boat launches, coastal recreational facilities (i.e., public parks, boardwalks, fishing piers,

beaches), and festivals and events within Charleston and Beaufort counties South Carolina that provided us with access to stakeholders (i.e., tourists and residents).

Sampling

The surveys were administered to stakeholders who are age 18 or over and have either seen or used the intercoastal waterways (i.e., tidal creeks and rivers) in Charleston or Beaufort Counties. Coastal stakeholders were intercepted using a random sampling technique. Sampling efforts were approximately equally distributed between Charleston and Beaufort counties South Carolina. Intercepts occurred primarily in communities/ waterfronts near areas open to mariculture permitting. Through 22 days of data collection spread out over 5 data collection trips (September 2nd – 5th, September 16th – 18th, October 6th - 8th, November 5th – 7th, and February 18th – 19th), 383 surveys were administered and completed with a 67% response rate. Survey locations were as follows: Folly Beach Co. Park, Mt. Pleasant Pier, SeaIsland Farmers Market, James Island Co. Park, Palmetto Island Co. Park, Shem Creek Park, Bluffton Farmers Market, Henry C. Chambers Waterfront Park (Beaufort Shrimp Festival), and Marion Square (Southeast Wildlife Expo). A secondary sample of 34 respondents in Charleston County were chosen at random to participate in the VR portion of the survey. All 34 participants were able to view Panel B, with 32 participants able to view both Panels B and C (as described in the next section).

Survey and Visual Elements

The survey included questions to first understand those sampled, and specifically their use of coastal resources and oysters. These questions asked about home zip code, intercoastal property ownership, what purposes respondents used tidal creeks and rivers

for, and how many times they used these places in the last year. Similarly, respondents were asked if they eat oysters, how often they do so, and if their oysters were wild or farm raised.

A series of survey questions measured perceptions towards oyster mariculture, and related issues and benefits. Specifically, respondents were asked to list three words or phrases to describe their feelings towards oysters raised in farms (i.e., mariculture). Next, they rated their opposition or support to farming of oysters on a seven-point Likert-type scale from -3 (‘Strongly Oppose’) to 3 (‘Strongly Support’), with 0 representing a neutral response.

Respondents were presented a list of 13 potential concerns and 9 potential benefits often associated with oyster farms (Tables 3.1 and 3.2). The concerns are based on a review of the literature and public news articles related to oyster mariculture in SC (e.g., Johnson, 2020, 2021; Smith, 2021). The concerns were not necessarily based on scientific or objective information. Rather, the potential benefits were based on scientific or objective information associated with oyster farming (e.g., S.C. Sea Grant Consortium, 2023b).

Additionally, the study attempts to build upon and improve the use of visual methods for measuring normative thresholds by applying it to the perceptions of oyster mariculture (Dalton et al., 2017, Manning, 2007). Four visual elements were used in coordination with the survey (Figures 3.1 through 3.3; 360° IVR video for 300 cages, ,https://youtu.be/et4LdfYJauc, and 360° IVR video for 900 cages, https://youtu.be/_Eph_ucie0Y, to depict a range of indicator levels and conditions. Both

traditional 2D photos and 360° camera photos and video displayed with a head mounted display (HMD) were used to show the visual elements to survey respondents.

First, 2D photos in Figure 3.1 represented the view of an oyster farm in South Carolina with floating cages from "Up Close" and "At a Distance." Respondents were informed about how typical mariculture farms are operated, licensed, and sited:

> *Please look at the pictures for Question 11 [*Figure 3.1*] in the binder you were given of the floating cages in a South Carolina oyster farm, from up close and far away. Farmed oysters are grown in cages in public tidal creeks and rivers. Oyster farms are specifically permitted and overseen by state and federal agencies, according to specific guidelines. Some cages sit on the bottom, but newer cages float on the top of the water. Cages are often checked on or serviced daily for a few hours by the oyster farmer from a typical motorboat. The public still has legal access to and can use the waters in and around these oyster farms. A farm's location is placed to ensure that no more than one-third of any navigable channel is used and that that the farm is offset from the shoreline and major navigational routes.*

After reading this information, respondents were asked in an open-ended response format what concerns, if any, they have about oyster farms or eating oysters from these farms?

Second, simulated photos were constructed to portray how observing an oyster farm from different points of view (e.g., a developed or undeveloped shoreline, represented by the absence or presence of a dock) and from different distances (50m, 100m, 200m, 400m) affect respondents' ratings of acceptability (Figure 3.2). This was done through a series of eight 2D photographs viewed in a traditional 8"x10" color

printed format. Three hundred cages were represented in each photo, which is a current size of an oyster mariculture operation in SC. Respondents were asked how acceptable each photo was on a 9-point Likert-type scale of acceptability (-4 = "Very Unacceptable and +4 = "Very Acceptable"). Respondents were also asked which photo represented the closest to them that an oyster farm should be permitted to occur by agencies.

Third, Panel B (Figure 3.3) consisted of eight 360° photographs displayed through an HMD. This data collection consisted of the secondary sample of 34 participants. Photographs of a current oyster farm in SC were taken with an AletaS2 360° camera and rendered using Adobe Photoshop and PremierPro to stitch the photographs together to create the VE. A PICO 4 HMD was used to display the VE to create a realistic IVR that virtually placed the participant at the bow of a boat and showed them oyster farm sizes of 300 (the current condition of the existing oyster farm photographed), to 3,000 cages. Two different backgrounds were used in the VE to measure if location was a determining factor in acceptability. One background prominently displayed a major transportation bridge while the other displayed an undeveloped background. These backgrounds were chosen based on the results from pre-study focus groups with stakeholders, which are not reported here (Norman et al., 2020). Survey respondents were asked to take a seat in a rotating stool, to place the HMD on their face, and adjust the fit until the image they saw was clear. A rotating stool allowed for participants to explore all 360° of the IVR without needing to get up or walk around, limiting the amount of motion sickness they might feel while in the VE. Before displaying each VE to the survey participants, researchers requested each participant look at their feet to orient themselves to the bow of the boat, correctly identify which VE number they were being shown, and then they were

asked to explore the VE. When finished, researchers recorded how acceptable participants felt the size of the oyster farm was on a 9-point Likert-type scale of acceptability (-4 = "Very Unacceptable" and +4 = "Very Acceptable"). Respondents were also asked which photo shows the largest oyster farm that should be permitted along a waterway by agencies.

The fourth and final visual element for this survey was presented in Panel C (Table 3.3). This data collection consisted of 32 out of the 34 participants from the secondary sample. Respondent attrition accounted for the somewhat smaller sample size. This phase consists of 4 narrations of hypothetical conditions and two IVR videos. Each of these videos were created using the same techniques as Panel B. The videos place the participant at the bow of a boat, driving along an intercoastal waterway where they see themselves driving past an oyster farm. These videos, and accompanying narrations, provide context for experiencing various sizes of oyster farms during a typical water recreation activity (i.e., boating). By utilizing a moving IVR, researchers can add even more sensory information to the participants. The added sensory information not only allows for participants to be placed on a boat in the presence of an oyster farm (i.e., IVRs from Panel B) but creates the realistic experience of going by an oyster farm on a boat in real-time. The two videos create the experience of going by an oyster farm with 300 cages (current condition) and an oyster farm with 900 cages (3x current condition). The first IVR video lasted for 40 seconds and the second IVR video lasted for 2 minutes. The narrations for this portion of the survey went as followed: "*Imagine yourself traveling full speed on a motorboat down an intercoastal waterway. On your right side is an oyster farm of [300, 900, 1500, 1800 cages] that goes the length of the waterway for*

about [40 seconds, 2min, 3:30min, 4min]. How acceptable or unacceptable would this experience be for you?" Each narration provides the context of an oyster farm size and the appropriate time it would take to pass such a farm at the speed that is displayed through the IVR videos. When finished, researchers recorded how acceptable participants felt the size of the oyster farm was on a 9-point Likert-type scale of acceptability (-4 is "Very Unacceptable and +4 is "Very Acceptable") and asked the largest number of cages an oyster farm that should be permitted by agencies.

ANALYSIS

Survey results were entered into an SPSS software database for processing and analysis. Means testing analyses were used to investigate differences between measured variables. Thematic analyses were utilized to code open-ended responses to gain further understanding of the public's perceptions of oyster farming. Social norm curves were used to analyze and report data related to evaluations of photo simulations and related thresholds. Social norm curves plot the mean, aggregate evaluations for a range of conditions for each selected indicator. The Potential for Conflict Index (PCI2) for each evaluation is displayed on each norm curve to help understand the amount of consensus about each norm-based threshold (Manfredo, et al., 2003). PCI2 is a scale that ranges from 0 to 1 with scores closer to zero indicating more consensus among respondents while scores closer to one indicating less consensus. The size of the circles on the social norm curve help depict this visually with smaller circles indicating smaller PCI2 scores while larger circles indicate a higher PCI2 score.

RESULTS

Characteristics of Participants

A representative sample of 383 coastal stakeholders were surveyed in the Fall of 2022 and Spring of 2023 with a response rate of 67%. This sample size produced overall survey results with a 5.1% confidence interval (at a 95% confidence level). Almost three-quarters of our participants (73.9%) reported being residents of either Charleston or Beaufort Co., SC, 20.4% reported being tourists and the remaining 1.8% reported working in these counties but living elsewhere. Of the 275 respondents that reported living in the counties of focus, 25.1% reported owning land in view of a coastal waterway. Our participants also reported utilizing the tidal creeks and rivers for a number of recreational activities including scenic viewing from land (68.2%), recreational boating (58.6%), fishing or shrimping (44.1%), oyster harvesting (9.9%), and other activities (4.4%) including paddling and beach-going. A small percentage of our participants (6.8%) also reported utilizing the tidal creeks and rivers for work purposes. It should also be noted that out of the 383 participants in this survey, only 77 (20.1%) reported not eating oysters. Finally, when asked directly how much they knew about oyster farming and farmed oysters, 46.6% self-reported as having *No Knowledge* while 40.7% self-reported as knowing *A Little*. Meanwhile, 10.1% of our sample self-reported as having *A Good Bit* of knowledge and only 2.6% expressed having *A Lot* of knowledge about oyster farming.

Stakeholder Perceptions of Oyster Mariculture Development

Participants were asked to list up to three words or short phrases that described their feelings towards oysters raised in farms. An iterative coding process was conducted

by a single coder to identify themes and perceptions for each of the open-ended questions included in the survey. Through a thematic analysis, it was discovered that 55% of total responses reflected a *Positive* outlook associated with oyster farming. Sustainability, local sourcing, ecological benefits, and a general love of oysters were common themes among those with positive feelings. The second most frequent outlooks towards oyster farming were *Negative* and *Unsure* (14% each). Those who reflected a more *Negative* outlook had concerns about the quality of oysters (e.g., taste and cleanliness) and a general negative opinion of farmed seafood. Those who expressed an *Unsure* feeling about oyster farming reflected a sense of unknowing or lack of knowledge on the subject. The next three themes that were the most prevalent were *Mixed,* sets of words or phrases that had both positive and negative association, *Neutral*, those who expressed neither positive or negative feelings towards oyster farming, and *No Opinion*, those who expressed a lack of interest in the topic. Each of these themes represented 5% of the sample. The final 1% of respondents listed words or phrases that did not quite fit the purpose of the question and could not be coded into any of the other themes.

Participants were then explicitly asked to rate how much they supported or opposed the farming of oysters on a 7-point Likert-type scale from -3 (Strongly Oppose) to +3 (Strongly Support) (Table 3.4). A majority of participants (60%) reported being relatively neutral (answering -1, neutral, or +1) on the matter with the most common reported reasons being lack of knowledge and having no opinion of oyster farming. Those who were more favorable of oyster farming (answering +3 or +2; 35%) reported this support being related to the sustainability of oyster farming, it's benefits to the local ecosystem (i.e., improved water quality and reduced harvesting pressure on wild oysters),

and its connection to the local area (i.e., culturally, economically). Those who were less favorable of oyster farming (answering -2, or -3; 5%) reported this opposition being linked to their concerns about both social (i.e., aesthetics, impacts on local wild harvesters) and ecological impacts (i.e., water quality due to increased activity), and their distaste for farm-raised seafood. All respondents were asked directly if oyster farming fit into the local culture, and 69.5% of respondents believed that oyster farming did.

Participants were then given a narrative describing how typical mariculture farms are operated, licensed, and sited (see Methods section) and two photographs of a typical oyster farm, one from "Up Close" and "At A Distance" (Figure 3.1). Participants were asked to list any concerns they might have about oyster farming or eating the oysters out of farms. Through the thematic analysis, twelve themes emerged. The largest theme that emerged was *No Concern* which accounts for 51% of our sample. *Environmental Impacts* (14%) and *Boating Hazards* (12%) were the next most prevalent themes among our sample, with *Limits to Public Access*, *Quality of Product* (5% each), and *Aesthetics* (4%) following these. The final six themes contained less than 10 individual responses including *Regulations* (3%), *Sighting* (1%), *Economic* (1%), *Should Not be Allowed* (1%), *Difference from Wild Oysters* (1%), with *Off Topic Responses* accounting for 2% of responses.

Table 3.1 displays the results of how concerned participants were about oyster farming based on a given a list of potential perceived or anecdotal scenarios on a 5-point scale (-2, Big Concern, to +2, Not a Concern). The results of this table show that the most concerning scenarios were ownership of farms being from outside South Carolina (-0.63), oyster cages breaking loose (-0.42), loss of access of public waterways (-0.27), and

boating safety (-0.25). Participants also rated the possible negative impacts of oyster farming had on wild oysters (-0.16) and the environment in general (-0.07) as scenarios of *Big Concern.* The least concerning scenarios include good management and operation of oyster farms (-0.06), aesthetic concerns (0.05), farms being too near bridges and cities (0.09), and the use of public waterways for commercial purposes (0.02).

Participants were then asked to rate a series of scientific and objective factors about the possible social or environmental benefits of oyster farming on the same 5-point scale based on importance (-2, Not Important, to +2, Very Important; Table 3.2). All factors received a positive mean rating with improvements to water quality (1.18) being the highest rated and the use of standard practices of oyster farming (0.91) being the lowest rated factor.

After participants were exposed to more information about oyster farming through their participation in this survey (i.e., photographs and a narrative explaining oyster farming, potential perceived or anecdotal scenarios, and scientific and objective factors about oyster), researchers again asked how much they supported or opposed oyster farming. The results show that there was a significant rise in support for oyster farming ($t(353)= 6.32$, $p < 0.01$, $M=0.88$ and $M=1.31$, respectively) when asked after given more information. *Strongly Support* received the largest share of responses (27.5%) after the introduction of survey information (Table 3.5).

Norm-based Thresholds for Viewing Oyster Mariculture

Panel A- Distance to Oyster Farm

The first series of images (Figure 3.2) asked participants to rate the acceptability of the distance between themselves on shore and an oyster farm along with the context in

which the oyster farm is located. The social norm curve for Panel A (Figure 3.4) depicts mean acceptability ratings based on viewing distances of 50m, 100m, 200m, and 400m from shore. It also depicts whether or not the presence of development, as portrayed by a dock, has any effect on acceptance (shown by checkered circles).

The low PCI2 values suggest that there is a relative consensus about the acceptability level for each presented condition. Overall, there was no combination of distance and development that reached an unacceptable condition of an oyster farm of 300 cages. All eight conditions remained above the "0" acceptability threshold. One general trend that emerged was that as distance increased, so did acceptability. The increases in acceptability were modest ranging from 0.75 to 1.56 for undeveloped and 0.23 to 1.66 for developed (i.e., when a dock was present). There were significant differences in acceptability between proximity groups and amount of development. At 50m, development had a significantly lower acceptability $t(309)= 6.01$, $p < 0.01$. The same trend was also found at 100m ($t(306)= 3.1$, $p < 0.05$) and at 200m ($t(300)= 2.25$, $p<0.05$). At 400m, development had no significant effect on acceptability $t(291)= -1.37$, $p =0.17$.

Panel B- Size of Oyster Farm as a Block

The second series of images (Figure 3.3) asked participants to rate the acceptability of the size of an oyster farm, as shown as a block of cages in one area and were displayed through a PICO 4 HMD using 360° VR technology (n=34). The social norm curve for Panel B (Figure 3.5) depicts mean acceptability ratings based on the number of cages in one oyster farm. It also depicts whether the presence of development, in the form of a bridge, has any effect on acceptance (shown by checkered circles). There

is an overall trend that as the number of cages in an oyster farm increased, the acceptability decreased. Similarly, there seems to be growing disagreement about acceptability levels as the number of cages increases, as shown by increased PCI2 scores. Based on the results, the potential threshold for social acceptance of an oyster farm in a block formation would be 2,000 cages. In other words, if oyster farms reached a size over 2000 cages, the public, on average, would be unaccepting of their size. Few differences in acceptability occurred between oyster farms between 300 and 1,500 cages, and their placements near a developed area, like a major bridge, did not have a substantial influence on acceptability. Figure 3.5 also indicates that development (the presence of a bridge) did not have a significant effect on acceptability (300 cages ($t(33)= 0.92$, $p =0.36$) and 1,500 cages ($t(33)= 0.87$, $p=0.39$)).

Panel C- Size of an Oyster Farm as a Length of Tidal Creek

The third series of images asked participants to rate the acceptability of the size of an oyster farm, as a length of an tidal creek, through both a narrative format and 360° IVR video (n=32). The social norm curve for Panel C (Figure 3.6) depicts mean acceptability ratings based on the number of cages in one oyster farm. It also depicts whether or not the mode in which participants were asked (i.e., narrative or IVR) has any effect on acceptance (IVR is shown by checkered circles). The range of the number of oyster cages used for the 360° IVR video portion of the study, 300 and 900, was chosen to reduce response burden. The 360° IVR video containing 300 cages lasted 40 seconds where the 360° IVR video containing 900 cages was 2 minutes in length, and 360° IVR video duration would only increase further from there. This is why it was the researchers' decision to only show two 360° IVR videos during this section of the study.

The PCI2 values indicated that there was a modest amount of agreement in acceptability levels among our sample. A general downward trend of acceptability as oyster farm size increased was seen throughout the sample ranging from 1.75, narrative about 300 cage oyster farm, to -1.78, narrative about 1,800 cage oyster farm. These results suggest that the potential threshold for an oyster farm in a linear formation would be around 600 cages. Researchers did not find any significant difference in acceptability between the narrative and 360° IVR video distribution method for either the 300 cage ($t(31)= 1.54$, $p = 0.13$) or 900 cage oyster farms ($t(31)= -0.36$, $p =0.72$).

DISCUSSION

Stakeholder's Perceptions of Oyster Mariculture

The results of this study revealed several interesting and some counterintuitive findings. The first interesting finding is that even though oyster mariculture has been a contentious topic in the local news coverage of Charleston and Beaufort Counties, SC, the public still seemed to express having little to no knowledge about oyster farming (87.3%). This could be why stakeholders first reported being neutral when it came to supporting or opposing the practice of oyster farming (Figure 3.5). However, the focus on oyster mariculture in recent years may have also contributed to the limited percentage of participants who selected "*Don't Know*" throughout the survey (0.8% to 15.8%). This compares to a similar study from 2015 (Jodice et al.), which revealed that 56% of tourists and 37% of residence were not even aware of the existence of mariculture in their destination/community. The current study seems to show that oyster mariculture has become a more familiar topic to stakeholders in Charleston and Beaufort Counties, but

when asked to explain their neutrality for oyster mariculture, *Lack of Knowledge* remains the most common response. These results reveal an interesting development within the stakeholders' perceptions of oyster mariculture that even though they may be becoming more aware of the practice, they admit not knowing much about it. This would point to insufficiencies in public messaging and education. News reports and articles are being seen by the public but they lack the informative and objective scientific information that the public needs to create educated, well thought out opinions about oyster farming.

The findings from Figure 3.6 also seem to support a hypothesis that *Lack of Knowledge* seems to be an issue among stakeholders in Charleston and Beaufort Counties, SC. When participants were asked to rate their level of concern based on a list of potential perceived or anecdotal scenarios involving oyster farms, all of the mean ratings seemed to be almost ambivalent or neutral while the standard deviations for the same scenarios were also relatively high. This could be a result of having limited encounters with oyster farms, combined with a lack of knowledge, making it difficult for participants to relate to the scenarios, which may be causing participants to not have strong opinions on the issue. With only 17 permitted oyster farms in SC and 10 of them possessing floating cages, the most visible form of oyster farming, there are very limited opportunities for stakeholders to have interacted with a real oyster farm.

What is counterintuitive about these results is that we do not see this same ambivalence in Figure 3.7. When participants were asked to rate the importance of a series of scientific and objective factors about oyster mariculture, all factors received a positive mean rating with lower standard deviations compared to Figure 3.6. This would indicate a much stronger consensus among the participants when given these factors.

These results could mean that when stakeholders are provided with even limited information about oyster farms, their perceptions become more crystallized.

This would coincide with the results discovered after participants were exposed to more information about oyster farming through their participation in this survey. When asked again to report their level of support for oyster farming, the number of *Don't Know* responses reduced by half and standard deviation was lowered from 1.53 to 1.15 when compared to the first-time participants were asked the same question. The information provided throughout the survey could have been the catalyst for that change. This again supports that there is an absence of informative, objective scientific information and interpretation opportunities that the public needs to create educated, well thought out opinions about oyster farming.

Normative Thresholds for Oyster Mariculture Using Traditional Visual-Based Methods

The use of traditional visual-based methods (i.e., through a series of eight 2D photographs viewed in a traditional 8"x10" color printed format; Manning, 2022) was utilized to assess distance and size thresholds for oyster mariculture. The results from Figure 3.4 show that both distance and development had significant effects on the acceptability of a 300-cage oyster farm. Distance provided for a modest, yet noticeable change in acceptability. The introduction of development generated significantly lower acceptability scores when compared to their non-development counterpart for three out of the four cases. PCI2 scores were also slightly higher when development was present, meaning that the introduction of development caused there to be a higher degree of disagreement among stakeholders. The overall takeaway, however, is that the low PCI2 values suggest that there is a relative consensus about the acceptability level for each

presented conditions and that stakeholders generally agree about what is acceptable and what is not. These results could suggest that the NIMBY sentiment could still be a problematic hurdle for mariculture expansion in this region as this aligns with similar findings from Duffy et al. (2016). It is interesting, however, that none of the provided conditions, neither distance nor development or any combination of the two, violated the normative threshold of minimal acceptability. This means that even though acceptability was lowest when it was closest to development, that stakeholders would still be accepting of being in the presence of oyster mariculture production.

Normative Thresholds for Oyster Mariculture Using VR Imagery

Panel B (Figure 3.3) consisted of eight 360° VR still photographs displayed through a PICO 4 HMD. The results from Figure 3.5 display a pattern of decreased acceptability as the number of cages within an oyster farm increased. At 2000 cages, the normative threshold of minimal acceptability is violated, indicating that if oyster farms in a block formation are to grow to 2000 cages or larger, the public would begin to not accept them. Similarly, the normative threshold of minimal acceptability would be violated if linear formation oyster farms grew to become 600 cages or more. These represent the social carrying capacities of oyster mariculture in this study's context. When asked directly about which image best represented the greatest number of cages that an oyster farm should have, the mean result was 1,378 cages with the median response of 1,500 cages. These results confirm what is depicted by Figure 3.5, which shows that there is relatively little change in acceptability from 300 cages to 1,500 cages, with the inflection point (i.e., largest decrease in acceptability) coming between 1,500 and 1,800 cages.

The figure also shows us that even though acceptability scores decreased when an oyster farm is in the presence of a major bridge, it did not have a significant effect on acceptability when shown with the same number of oyster cages. These results were surprising based on qualitative data collected during the first phase of this project which showed that location (i.e., places near bridges and major transportation routes) was an indicator for the acceptability of oyster mariculture. What is also surprising is that the level of consensus among stakeholders decreases (higher PCI2 scores) with the introduction of a bridge. This would seem counterintuitive to the results referenced from phase one but seem to agree with the results from Figure 3.4 and Panel A. In both instances, PCI2 scores increased with the introduction of development when compared to their respective undeveloped counterparts. This further exemplified that there is uncertainty among stakeholders when it comes to the presence of oyster mariculture within developed intercoastal areas.

The final set of initial results can be seen in Figure 3.6 where a mix of narrative and 360° IVR video approaches were used to measure acceptability scores for the potential size of an oyster farm in SC when displayed as a length of an intercoastal channel and not in a block of cages in an open area. We continue to see the general trend we saw in Panel B where when number of cages increase, acceptability decreases. This time, however, the inflection point is between 300 and 900 cages. Similarly, a maximum of 600 cages along a channel length could be used as a threshold for the social carrying capacity of mariculture development if farms are established as linear farms in narrow intercoastal channels.

The implications of these differences in acceptability between Panel B, block arrangement oyster farming, and Panel C, linear arrangement oyster farming, shows that the public could be more accepting of oyster farming if it were concentrated in a particular area rather than being strung out along intercoastal waterways and channels. If this were to be true, policy makers would want to favor permits proposing more concentrated arrangements of oyster farming. This style of farming would also allow for oyster farmers to possess more cages within their farms, creating more profit, while still remaining within the public's acceptability of the practice.

A Deeper Dive into Delivery Method and Acceptability Scores

When we compare the three different delivery methods for measuring the acceptability of the number of cages an oyster farm should have (i.e., 360° VR, still photographs, 360° IVR videos, and narratively), there are some interesting findings. Table 3.5 shows the results of multiple paired *t*-tests that help us determine if there were any significant differences in acceptability score depending on delivery method. When we compare 360° VR still photographs and narrative delivery, there are significant differences in acceptability scores for both 300 and 900 cages ($t(31)= 2.23$, $p = 0.03$) and ($t(31)= 6.48$, $p <0.001$), respectively). We also see that there are significant differences when we compare 360° VR still photographs and 360° IVR videos for 300 and 900 cages ($t(31)= 1.31$, $p = 0.001$) and ($t(31)= 6.16$, $p <0.001$), respectively). We did not, however find significance between narrative and 360° IVR videos, as reported on in the results section. The authors have developed several reasons as to why we are seeing these differences in acceptability score based on delivery method even though participants are rating their acceptability for the same number of cages. The first thought is that when we

displayed the 360° VR still photographs in Panel B, the authors did not tell the participants how many cages were being represented in each photograph. However, during both the narrative and 360° IVR videos, we intentionally mentioned the number of cages to consider when assessing their acceptability. Another possible reason the authors think that there were significant differences between 360° VR still photographs and 360° IVR videos is the monotony of the videos. As mentioned in the methods, each 360° IVR video immersed the participant on the bow of a boat driving past an oyster farm. Although the IVR experience might be novel to some, the videos themselves can be very repetitive. The videos were also 40 seconds (300 cages) and 2 minutes (900 cages) each of which could have resulted in an increased response burden, increasing our likelihood of recording lower acceptability ratings. The 360° IVR video and narrative portion of the survey was also the last section of the survey and participant fatigue could have been a factor in the lower acceptability scores for these methods.

Using HMDs to Measure Social-Norms in a Field-Based Setting

Advancements in technology and the growing accessibility of VR to researchers has allowed us, as a field, to explore the capabilities of VR to improve visual-based methodological research. It was important for the researchers to test the efficacy of HMD use in the field to expand the boundaries of its use and enable researchers to reach our target sample populations. The utilization of VR technologies does, however, come with caveats, especially in a field-based setting.

Challenges with Equipment

Some of the hurdles we faced while determining the feasibility of using HMDs in a field-based setting were the logistics of use when access to electricity and connectivity

are limited. The average battery life for the leading HMDs (e.g., Oculus, PICO, HTC) is marketed as 2-3 hours on a single charge but are more commonly reported by users to be around 1-2 hours of constant use on one single charge. Connectivity to Wi-Fi was also a consideration because specific HMDs and imaging software utilized to display VR imagery rely on internet connection to function. Connectivity is also important in the context of research because without the ability to 'cast' the view of our participants, it can be difficult to direct users to correctly explore the IVR while making sure not to lead participants to observe specific elements of the IVR. This creates the need for very clear and precise communication between the researcher and the participant while the study is being conducted. A review of VR and HMD research found that the studies utilizing this technology are typically conducted in lab-type settings (Armougum et al., 2019; Browning et al., 2020; Chirico & Gaggioli, 2019; Farooq et al., 2018; Fisher-Gewirtzman, 2018; Smith, 2015; Wang et al., 2020). These settings address each of these mechanical concerns due to the ample resources available to researchers in lab-type settings.

To address the issue of limited electricity in the field, researchers in this study utilized a 300W portable power lithium battery generator. Between each participant, researchers made sure to charge the HMD while it was not in use. During data collection, however, we had to eventually pause our efforts several times throughout data collection due to low battery warnings. As a result, this limited our ability to recruit more participants.

Researchers were able to navigate the hurdle of limited connectivity by finding a VR imagery application (i.e., Skybox VR Video Player, PICO File Manager) that would

allow for offline display. With this application and the addition of ample built-in memory storage of the PICO 4 HMD, we were able to eliminate limited connectivity as a barrier to HMD usage in the field. One final equipment challenge we faced was that PICO Global does not suggest the use of its product in outdoor settings. Their website states that "The controller adopts an optical solution for tracking, and outdoor sunlight will interfere with the tracking of the controller. Currently, it is not supported for outdoor use." (PICO Global, n.d.). Although there were some issues with the HMD recognizing the controllers, these issues were not as severe as the warning suggests as this research was conducted in the shade and did not impact data collection.

Challenges with Implementation and Participant Engagement

Along with some equipment hurdles, researchers encountered some challenges administering the survey through the HMD. As previously stated, the lack of connectivity to Wi-Fi resulted in an inability to 'cast' the view of our participants causing there to be a heavy reliance on clear and constant communication between researchers and participants. For each VR image that was displayed in the HMD, participants were asked to orient themselves to the bow of the boat, report what number they saw, and then were asked to explore the VE before reporting their acceptability score (further described in the methods section). This exchange between participant and researcher had to happen before each of the VE that were shown and then repeated for the IVR videos that were displayed. The most difficult part of this exchange was when participants asked to go back and view some of the VR images over again to answer which VR image best represented the largest number of cages an oyster farm should have and be permitted by agencies. Even though the researchers wish this process would have gone more smoothly,

participants seemed not to mind and did not show or express any signs of frustration during the survey process.

Another hurdle that researchers had to prepare for was the range in familiarity and comfortability with VR technology among the sample population. Where this research differs from other VR studies is its focus on using a more generalizable sample. Compared to a few previous VR studies that mainly utilize college students as their sample (Armougum et al., 2019; Browning et al., 2020; Chirico & Gaggioli, 2019; Farooq et al., 2018; Fisher-Gewirtzman, 2018; Smith, 2015; Wang et al., 2020), the participants for this research were all selected at random from the public. This resulted in an age range of 19 to 79 with a mean age of 38.9 years old. Only one third of participants had ever had any experience with VR technology. This, however, turned out to not be as big of an issue as previously though. None of the participants reported any signs of cybersickness, a combination of the symptoms of discomfort and malaise produced by VR exposure (Weech et al., 2019), and none of our participants seemed to show any adverse reactions to the technology.

Although there are several considerations that need to be well thought out before utilizing VR technology in the field, the authors hope that this exploration shows that the utilization of VR technology is not out of reach for field-based research. Even though we had a relatively small sample size for this portion of the project (n=34 for just 360° VR still images and 32 for 360° VR still images and 360° IVR video), we did not encounter any equipment or procedural complications that would deter us from further utilizing VR technologies as a tool in the field.

CONCLUSIONS

The importance of this research is that it will provide empirical data for informed management of oyster mariculture in counties along the SC coast where coastal resources predominate, including viewshed and working waterfronts. These areas are under pressure for being sustainably managed, economically productive, recreationally accessible, and not distracting from the scenic beauty of the SC Lowcountry. Oyster mariculture, if managed properly, is an industry that has the potential to coexist with other prominent coastal industries such as tourism and commercial fishing, in a way that is economically and ecologically viable into the future. The results of this study highlight the importance of consistent and scientifically factual messaging when it comes to educating the public about oyster mariculture. Even with the increased attention oyster farming has had in the public sphere over the recent years, there is still a large faction of the stakeholder population in SC that possesses limited to no knowledge about the practice. Even within this sample, we can see that just a small amount of information might be enough to inform stakeholders and to help them make informed decisions about oyster mariculture. It also suggests that an informed SC public is, on average, supportive of oyster mariculture. The results indicate that the social carrying capacity for oyster farming is well above the current condition of 300 cages (600 cages for linear arrangement and 2000 cages for a block formation farm) suggesting that the expansion of the practice would be accepted by the public.

This research also adds to the growing scientific literature regarding VR technologies and its capabilities in normative thresholds research through visual-based methods. 360° VR imagery technology, both still photographs and video, enable

researchers to immerse participants in environments and situations that are normally out of reach during survey research that uses traditional visual-based methods. Although the use of this technology comes with some added considerations, especially when deployed in the field, the researchers suggest that this is only the first step in the application of this technology for field-based normative research that utilizes visual-based methods. The next steps of this research should consider more direct comparisons between traditional visual-based methods and 360° VR still photographs for a given variable. This would open the door and allow researchers to test whether 360° VR technologies allow us to assess the acceptability thresholds more accurately and effectively for a given condition within a population.

REFERENCES

Altman, I. (1975). *The environment and social behavior: Privacy, personal space, territory, crowding*. Monterey, CA: Brooks/Cole Publishing Company.

Anderson, D. H. (1984). *Displacement: One consequence of not meeting people's needs.* USDA Forest Service general technical report NE-United States, Northeastern Forest Experiment Station.

Armougum A, Orriols E, Gaston-Bellegarde A, Joie-La Marle C, Piolino P (2019) Virtual reality: a new method to investigate cognitive load during navigation. *J Environ Psychol* 65:1–15

Bacher, K. (2015). *Perceptions and misconceptions of aquaculture: a global overview*. Retrieved June 10, 2017from http://www.fao.org/in-action/globefish/publications/details-publication/en/c/360636/

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological inquiry*, *13*(2), 103-124.

Brown, T. C., Richards, M. T., Daniel, T. C., & King, D. A. (1989). Recreation participation and the validity of photo-based preference judgments. *Journal of Leisure Research*, 21(1), 40-60.

Browning, M. H., Saeidi-Rizi, F., McAnirlin, O., Yoon, H., & Pei, Y. (2021). The role of methodological choices in the effects of experimental exposure to simulated natural landscapes on human health and cognitive performance: A systematic review. *Environment and Behavior*, *53*(7), 687-731.

Brownlee, M., Hallo, J., Jodice, L., Moore, D., Powell, R., & Wright, B. A. (2015). Place attachment and marine recreationists' attitudes towards offshore wind energy development. *Journal of Leisure Research*, *47*, 263-284.

Chirico, A., & Gaggioli, A. (2019). When virtual feels real: Comparing emotional responses and presence in virtual and natural environments. *Cyberpsychology, Behavior, and Social Networking*, *22*(3), 220-226.

Chu, J., Anderson, J. L., Asche, F., & Tudur, L. (2010). Stakeholders' Perceptions of Aquaculture and Implications for its Future: A Comparison of the USA and Norway. *Marine resource economics*, *25*(1), 61-76.

Coffey, A. J., & Atkinson, P. A. (1996). Narratives and stories. In *Making sense of qualitative data: Complementary research strategies* (pp. 54–82). Thousand Oaks, CA: Sage Publications.

Colburn, L. L., Jepson, M., Weng, C., Seara, T., Weiss, J., & Hare, J. A. (2016). Indicators of climate change and social vulnerability in fishing dependent communities along the Eastern and Gulf Coasts of the United States. *Marine Policy, 74*, 323–333.

Cribbs, T. W., Sharp, R. L., & Brownlee, M. T. (2019). Evaluating the influence of photo order on park visitors' perceptions of crowding at Buffalo National River. *Leisure Sciences*, 1-19.

Dalton, T., Thompson, R., Jin, D. & Katzanek, A. (2016). *What do people think about shellfish aquaculture in RI coastal waters?* NOAA Social Coast Forum 2016, Charleston, SC.

Duffy, L., Norman, W.C., & Jodice, L. (2016). *Stakeholder perspectives on mariculture and tourism interaction in coastal communities in South Carolina and Florida*. Presentation for NOAA Social Coast, Charleston, SC, Feburary 9-11, 2016.

Elliott, D. (2017). *7 years after BP oil spill, oyster farming takes off*. Retrieved on June 14, 2017 from http://www.npr.org/sections/thesalt/2017/06/10/532102196/7-years-after-bp-oil-spill-oyster-farming-takes-hold-in-south

Farooq, B., Cherchi, E., & Sobhani, A. (2018). Virtual immersive reality for stated preference travel behavior experiments: A case study of autonomous vehicles on urban roads. *Transportation research record*, *2672*(50), 35-45.

Filgueira, R., Comeau, L. A., Guyondet, T., McKindsey, C. W., & Byron, C. J. (2015). Modelling carrying capacity of bivalve aquaculture: a review of definitions and methods. Fisheries and Oceans Canada, *Ecosystems and Oceans Science*.

Fisher-Gewirtzman, D. (2018). Perception of density by pedestrians on urban paths: An experiment in virtual reality. *Journal of Urban Design*, *23*(5), 674-692.

Graefe, A. R., Vaske, J. & Kuss, F. R. (1984). Social carrying capacity: An integration and synthesis of twenty years of research. *Leisure Sciences, 6*, 395-431.

Graff, M. (2011). The Oyster Way. *Our State*. Retrieved on April 24, 2017 from https://www.ourstate.com/oysters/

Gupta N, Singh A, Butail S (2017) *The effect of instructional priming on postural responses to virtual crowds*. In: Paper presented at the 2017 IEEE virtual humans and crowds for immersive environments (VHCIE), Los Angeles, California

Hallo, J. C., Hughes, M. D., Brownlee, T. M., Manning, R. E. & Smith, B. L. (2012). *The carrying capacity of a protected barrier island: An application of a norm-based indicators and standards approach at Cumberland Island National Seashore*. Project report for the Cumberland Island National Seashore, National Park Service, 23 pp.

Clemson University Institute for Parks, Department of Parks, Recreation and Tourism Management, Clemson University.

Heydarian A, Carneiro JP, Gerber D, Becerik-Gerber B, Hayes T, Wood W (2015) Immersive virtual environments versus physical built environments: a benchmarking study for building design and user-built environment explorations. *Autom Constr* 54:116–126

Hudson K., & Murray J.M. (2015). *Virginia Shellfish Aquaculture Situation and Outlook Report, Results of the 2014 Virginia Shellfish Aquaculture Crop Reporting Survey.* Virginia Institute of Marine Science, Virginia Sea Grant Marine Extension Program.

Iachini T, Coello Y, Frassinetti F, Senese VP, Galante F, Ruggiero G (2016) Peripersonal and interpersonal space in virtual and real environments: effects of gender and age. *J Environ Psychol* 45:154–164

Jacobsen, R. (2016). The Essential Oyster: A Salty Appreciation of Taste and Temptation. New York: *Bloomsbury Publishing*.

Jepson, M., & Colburn, L. L. (2013). *Development of social indicators of fishing community vulnerability and resilience in the U.S. Southeast and Northeast Regions*. NOAA Technical Memorandum NMFS-F/SPO-129.

Jodice, L., Hull, J. & Sassenberg, U. (2009). *Aquaculture and tourism in the coastal zone: Conflict and innovation in New Zealand*. Presentation at Coastal Zone 09: Revolutionary Times: Catching the Wave of Change, July 19 to 23, 2009, Boston, Massachusetts.

Jodice, L. W., Norman, W. C. & Davis, J. (2015). *Perceptions of marine aquaculture in coastal tourism destinations in the US Southeastern Region*. Final Report submitted to SC Sea Grant Consortium, July 31, 2015.

Johnson, C. (2020, September 14). *New SC oyster farm raises concerns about floating hazards, growing industry*. Post and Courier. Retrieved March 13, 2023, from https://www.postandcourier.com/news/new-sc-oyster-farm-raises-concerns-about-floating-hazards-growing-industry/article_4fe7c920-33ac-11e9-b7ab-bfb68190dc80.html

Johnson, C. (2021, November 2). *Fight over floating oyster farms erupts anew as SC bill could pause summer harvest*. Post and Courier. Retrieved March 13, 2023, from https://www.postandcourier.com/news/fight-over-floating-oyster-farms-erupts-anew-as-sc-bill-could-pause-summer-harvest/article_a141a46c-7d1a-11eb-bad1-4311f0d5c4fa.html

Kecinski, M., Messer, K. D., Knapp, L., & Shirazi, Y. (2017). Consumer preferences for oyster attributes: Field experiments on brand, locality, and growing method. *Agricultural and Resource Economics Review*, 46(2), 315-337.

Kronqvist A, Jokinen J, Rousi R (2016) Evaluating the authenticity of virtual environments: comparison of three devices. *Adv Hum Comput Interact* 2016:2937632

Lacher, R., Oh, C., Jodice, L. & Norman, W. (2013). The role of heritage and cultural elements in coastal tourism destination preferences: A choice modeling–based analysis." *Journal of Travel Research, 52*, 534-546.

Lawson, S. R. & Manning, R. E. (2010). Tradeoffs among social, resource, and management attributes of the Denali Wilderness experience: A contextual approach to normative research. *Leisure Science, 24*, 297-312.

Louviere, J. J., Hensher, D., & Swait, J. (2000). *Stated choice methods: analysis and application*. New York: Cambridge University Press.

Manfredo, M. J., Vaske, J. J., & Teel, T. L. (2003). The potential for conflict index:A graphic approach to practical significance of human dimensions research. *Human Dimensions of Wildlife*, 8(3), 219–228.

Manning, R. E. (2011a). Indicators and standards in parks and outdoor recreation. In M. Budruk & R. Phillips (Eds.), *Quality-of-life community indicators for parks, recreation, and tourism management* (pp. 11-22) The Netherlands: Springer Publishing.

Manning, R. E. (2013). *Parks and carrying capacity: Commons without tragedy*. Island Press.

Manning, R. E., & Freimund, W. A. (2004). Use of visual research methods to measure standards of quality for parks and outdoor recreation. *Journal of Leisure Research*, 36(4), 557. doi:10.1080/00222216.2004.11950036

Manning, R. E., & Valliere, W. A. (2001). Coping in outdoor recreation: Causes and consequences of crowding and conflict among community residents. *Journal of Leisure Research*, 33(4), 410. doi:10.1080/00222216.2001.11949952

Mazur, N. A., & Curtis, A. L. (2006). Risk Perceptions, Aquaculture, and Issues of Trust: Lessons From Australia. *Society & Natural Resources, 19*, 791–808.

Miles, MB. & Huberman, AM. (1994). *Qualitative Data Analysis (2nd edition)*. Thousand Oaks, CA: Sage Publications.

Minnis, D. L. & Peyton, R.B.. (1995). Cultural carrying capacity: modeling a notion. Pages 19-34 in J. B. McAninch (editor). *Urban deer: a manageable resource*? Proceedings of the symposium of the 55th Midwest Fish & Wildlife Conference. North Central Section of The Wildlife Society, 12-14 December 1993, St. Louis, Missouri, US.

National Park Service. (1997). VERP: *The Visitor Experience and Resource Protection (VERP) Framework – A Handbook for Planners and Managers*. Denver, CO: National Park Service Denver Service Center.

Nielsen, J. M., & Shelby, B. (1977*). River running in the Grand Canyon: How much and what kind of use.* Proceedings River Recreation Management and Research Symposium, USDA Forest Service. General Technical Report, North Central Forest Experiment Station, USDA Forest Service, (NC-28), 168–177.

Neimark, J. (2016). *Why the Southeast could become the Napa Valley of oysters*. Retrieved on April 24, 2017 from http://www.npr.org/sections/thesalt/2016/01/27/462929374/why-the-southeast-could-become-the-napa-valley-of-oysters.

Norman, W. C., Hallo, J. C., Duffy, L. N., Jodice, L. W.,Fefer, J., Townsend, L., Koppa, E., & Peterson, B. (2020). *Development on the South Carolina coast: issues, factors, variables, and attributes influencing stakeholder perceptions examining the social carrying capacity for mariculture*. Paper presented at Aquaculture America 2020, February 9-13, 2020, Honolulu, Hawaii.

North Carolina Coastal Federation. (2016). *State of the Oyster: 2015 Progress Report*. Retrieved on April 24, 2017 from http://www.nccoast.org/wp-content/uploads/2014/12/8912-NCCF-Membership-Publication.pdf.

Patton M. Q. (2002). *Qualitative research and evaluation methods, 3rd edition.* Thousand Oaks, CA: Sage Publications.

Pettebone, D., Newman, P., Lawson, S. R., Hunt, L., Monz, C. & Zwiefka, J. (2011). Estimating visitors' travel mode choices along the Bear Lake Road in Rocky Mountain National Park. *Journal of Transport Geography, 19*, 1210-121.

PICO Global. (n.d.). *FAQs: Customer support: FAQs | Customer Support*. https://www.picoxr.com/global/support/faq

Pollnac, R. B., Seara, T., Colburn, L. L., & Jepson, M. (2015). Taxonomy of USA east coast fishing communities in terms of social vulnerability and resilience. *Environmental Impact Assessment Review, 55*, 136–143.

Puniwai, N., Canale, L., Haws, M., Potemra, J., Lepczyk, C., & Gray, S. (2014). Development of a GIS-Based Tool for Aquaculture Siting. *ISPRS International Journal of Geo-Information, 3*, 800–816.

Rossetti T, Hurtubia R (2020) An assessment of the ecological validity of immersive videos in stated preference surveys. *J Choice Model* 34:100198. https://doi.org/10.1016/j.jocm.2019.100198

Rudell, P. N. (2012). *Human perceptions and attitudes regarding geoduck aquaculture in Puget Sound, Washington: A Q methodology approach*. Retrieved on June 1, 2017 from https://digital.lib.washington.edu/researchworks/handle/1773/20860

Shelby, B. & Heberlein, T. (1986). *Carrying capacity in recreation settings*. Corvallis, OR: Oregon State University Press.

Shelby, B., Vaske, J. J., & Heberlein, T. A. (1989). Comparative analysis of crowding in multiple locations: Results from fifteen years of research. *Leisure Sciences*, 11(4), 269–291. doi:10.1080/ 01490408909512227

Smith, J. W. (2015). Immersive virtual environment technology to supplement environmental perception, preference and behavior research: a review with applications. *International journal of environmental research and public health*, *12*(9), 11486-11505.

Sieber, R. (2006). Public participation geographic information systems: A literature review and framework. *AAG Annals, 96*(3), 491–507.

Smith, G. (2021, May 9). *Shell Game: Conflict, secrecy cloud battle over SC Oyster Farming Permit*. Post and Courier. Retrieved March 13, 2023, from https://www.postandcourier.com/uncovered/shell-game-conflict-secrecy-cloud-battle-over-sc-oyster-farming-permit/article_f7919a3e-97c3-11eb-8282-eb15352bf9aa.html

S.C. Sea Grant Consortium. (2023a) *GIS-based South Carolina Mariculture Siting Tool*. Retrieved June 20, 2023, from https://www.scseagrant.org/gis-based-mariculture-siting-tool/

S.C. Sea Grant Consortium. (2023b) *Aquaculture in South Carolina*. Retrieved March 13, 2023, from https://www.scseagrant.org/aquaculture/

Stankey, G. H., & McCool, S. F. (1992). *Managing recreation use of marine resources through the limits of acceptable change planning system.* Unpublished paper. Missoula, MT: School of Forestry, University of Montana.

Strauss, A. & Corbin, J. (1990). Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Newbury Park, CA: Sage Publications.

Strickland-Munro, J., Kobryn, H., Brown, G., & Moore, S. A. (2016). Marine spatial planning for the future: Using Public Participation GIS (PPGIS) to inform the human dimension for large marine parks. *Marine Policy, 73*, 15–26.

Vaske, J. J., & Shelby, L. B. (2008). Crowding as a descriptive indicator and an evaluative standard: Results from 30 years of research. *Leisure Sciences*, 30(2), 111–126. doi:10.1080/ 01490400701881341

Wang, T. H., Wu, W. H., Shen, L., & Cheng, C. K. (2020). Exploring the validity of using immersive virtual reality technique on perceived crowding of recreational environment. *Landscape and Ecological Engineering*, 1-10.

Weech, S., Kenny, S., & Barnett-Cowan, M. (2019). Presence and cybersickness in virtual reality are negatively related: a review. *Frontiers in psychology*, 10, 158.

Whitmarsh, D. & Palmieri, M. G. (2009). Social acceptability of marine aquaculture: The use of survey-based methods for eliciting public and stakeholder preferences. *Marine Policy, 33*, 452–457.

Yu C-P, Lee H-Y, Luo X-Y (2018) The effect of virtual reality forest and urban environments on physiological and psychological responses. *Urban For Urban Green* 35:106–114

TABLES AND FIGURES

Table 3. 1: Frequency (%) and mean ratings of how participants answered the question *"Please indicate the extent that the following are concerns for you when considering your support or opposition to oyster farms. This list of concerns is based on potential perceptions, individual opinions, or your experiences, not necessarily on scientific or objective information."*

	Big Concern (-2) ←				→ Not a Concern (+2)	Don't Know	Mean	SD
Adequate permitting and oversight of oyster farms by governmental agencies	11.6	17.5	**22.4**	12.2	20.5	15.8	0.15	1.37
Oyster farms being too near things like bridges or cities	14.8	19.1	21.8	10.3	**23.3**	10.6	0.09	1.43
Oyster farms being unsightly, ugly, or ruining a scenic view	18.2	19.7	18.2	8.8	**26.2**	8.8	0.05	1.5
Using public waterways for commercial purposes	17.7	18.9	21.0	11.7	**21.9**	9.0	0.02	1.44
Good management and operation of oyster farms by their owners	19.4	18.2	17.2	12.3	**19.7**	13.2	-0.06	1.47
Negative impacts of oyster farms on the environment	**23.5**	14.5	16.1	9.4	23.2	13.2	-0.07	1.56
Negative impacts of oyster farms on wild oysters	**20.7**	19.5	16.7	9.3	18.9	14.9	-0.16	1.48
Oyster farms being too big	15.5	**25.7**	19.5	11.4	15.2	12.8	-0.17	1.34
Loss of access to or use of public waterways	**24.5**	20.7	18.9	10.2	17.3	8.4	-0.27	1.45
Navigating a boat safely around oyster farms	**25.5**	21.9	15.2	9.7	18.8	8.8	-0.28	1.49
Lack of on-site signage or marking of oyster farms	23.1	**24.3**	19.3	9.7	12.8	10.9	-0.4	1.36
Oyster cages breaking loose and becoming litter	**29.1**	23.2	15.0	9.8	16.2	6.7	-0.42	1.46
Oyster farms owned by those outside of South Carolina	**35.8**	17.3	18.6	7.9	11.9	8.5	-0.63	1.41

Table 3. 2: Frequency (%) and mean rating of how participants responded to the question *"Based on scientific or objective information, oyster farms are thought to be beneficial in the ways listed below. How important are these in helping you to decide your support or opposition to oyster farms?*

	Not Important (-2) ←				→ Very Important (+2)	Don't Know	Mean	SD
Oyster farms help filter excess nutrients from the water	4.4	4.7	9.3	21.4	**47.5**	12.6	1.18	1.14
Oyster farms help reduce harvest pressure on wild oysters	5.2	4.1	10.7	23.4	**44.9**	11.6	1.12	1.16
Oyster farms help provide economic benefits and local jobs	7.2	5.6	9.7	21.2	**47.9**	8.4	1.06	1.26
Oyster farms may provide habitat for other marine life	7.0	3.9	12.7	19.7	**45.9**	10.7	1.05	1.24
Oyster farms help provide a local food for restaurants and people	7.5	4.7	12.3	19.6	**47.5**	8.4	1.03	1.27
Farmed oysters are somewhat more sustainable and ocean-friendly than wild oysters	5.8	3.3	15.9	19.8	**43.2**	12.0	1.03	1.19
Oyster farms help provide a more reliable source for consumption	7.2	5.0	12.3	20.6	**45.7**	9.2	1.02	1.26
Oyster farms may produce oysters that are safer to eat	7.0	5.0	15.1	18.2	**43.7**	10.9	0.97	1.26
Very few oyster farms currently exist in South Carolina, but substantial potential and demand exists for their growth. The same equipment and techniques used frequently and for decades in other states could help increase the amount of oyster farming in the state and the benefits described above.	6.5	4.8	17.2	17.2	**38.4**	15.8	0.91	1.26

Table 3. 3: Panel C 360° IVR video and narration description (IVR displayed via HMD)

Video/ Narration number	Number of oyster cages and time it would take (minutes:seconds)	IVR created
Narration 1	"A farm with 300 cages (0:40)"	No
Narration 2	"A farm with 900 cages (2:00)"	No
Video 1	300 (0:40)	Yes
Video 2	900 (2:00)	Yes
Narration 3	"A farm with 1,500 cages (3:30)"	No
Narration 4	"A farm with 1,800 cages (4:00)"	No

Table 3. 4: Frequency (%) and mean ranges of how supportive or opposed participants were of oyster farming.

	Strongly Oppose (-3)			Neutral (0)			Strongly Support (+3)	Don't Know	Mean (SD)
How much do you support or oppose farming of oysters? (n=375) *(before survey information was presented)*	2.1	2.7	5.3	**44.3**	8.5	11.7	23.7	1.6	0.88 (1.53)
Considering the information in this survey, how much do you support or oppose farming of oysters? (n=365)	1.6	3.5	5.4	21.0	15.0	25.1	**27.5**	0.8	1.13 (1.15)

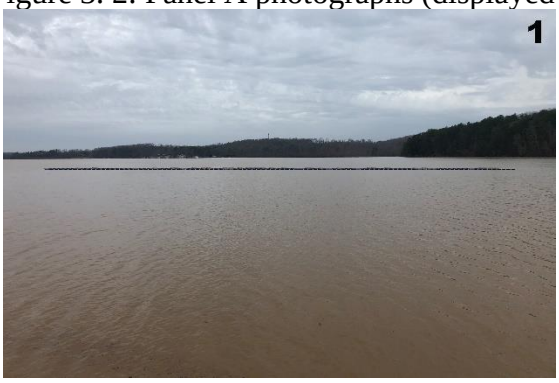
$t(353)= 6.32$, $p < 0.01$

Table 3. 5: Paired *t* tests for acceptability of 300 cage and 900 cage oyster farms based on information delivery method (N=32).

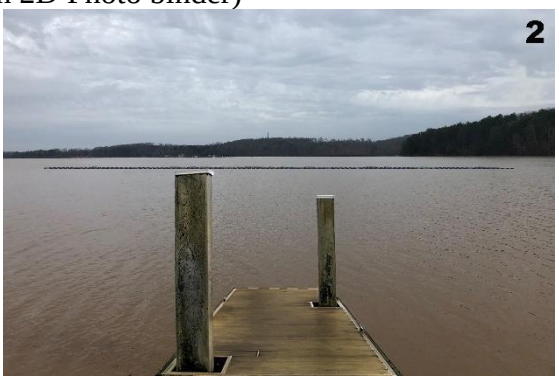
	300 Cages				900 Cages			
Method	Paired Mean Difference	SD	*t*	*p*	Paired Mean Difference	SD	*t*	*p*
360° VR Still Photographs Vs Narrative	0.5	1.27	2.23	**0.03**	2.69	2.35	6.48	<**0.001**
Narrative Vs 360° IVR Videos	0.31	1.15	1.54	0.13	-0.13	1.96	-0.36	0.72
360° VR Still Photographs Vs 360° IVR Videos	0.81	1.31	3.52	**0.001**	2.56	2.36	6.16	<**0.001**
df for all groups = 31								

Figure 3. 1: Photographs used for Question 11 (Oyster cages “Close Up” (left) & “At a Distance” (Right)

Figure 3. 2: Panel A photographs (displayed in 2D Photo binder)



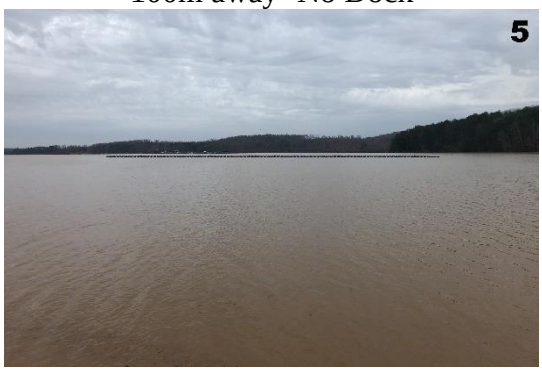
50m away- No Dock



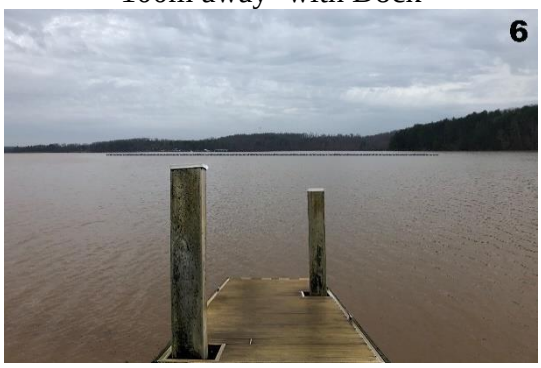
50 m away – with Dock

100m away- No Dock

100m away- with Dock



200m away- No Dock



200m away- with Dock

400m away- No Dock

400m away- with Dock

Figure 3. 3: Panel B 360° photographs (IVR displayed via HMD)

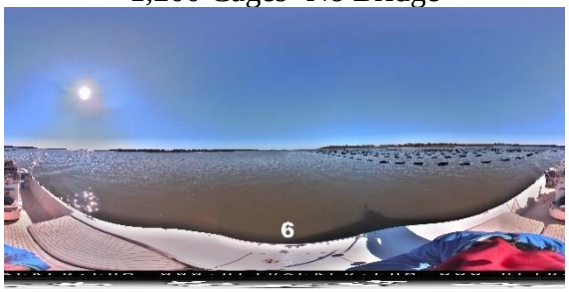
300 Cages- No Bridge

300 Cages – With Bridge

900 Cages- No Bridge

1,200 Cages- No Bridge

1,200 Cages- With Bridge



1,800 Cages- No Bridge

2,400 Cages- No Bridge

3,000 Cages- No Bridge

Figure 3. 4: Social norm curve (Mean, PCI2) for Panel A, observing an oyster farm from different points of view and from different distances.

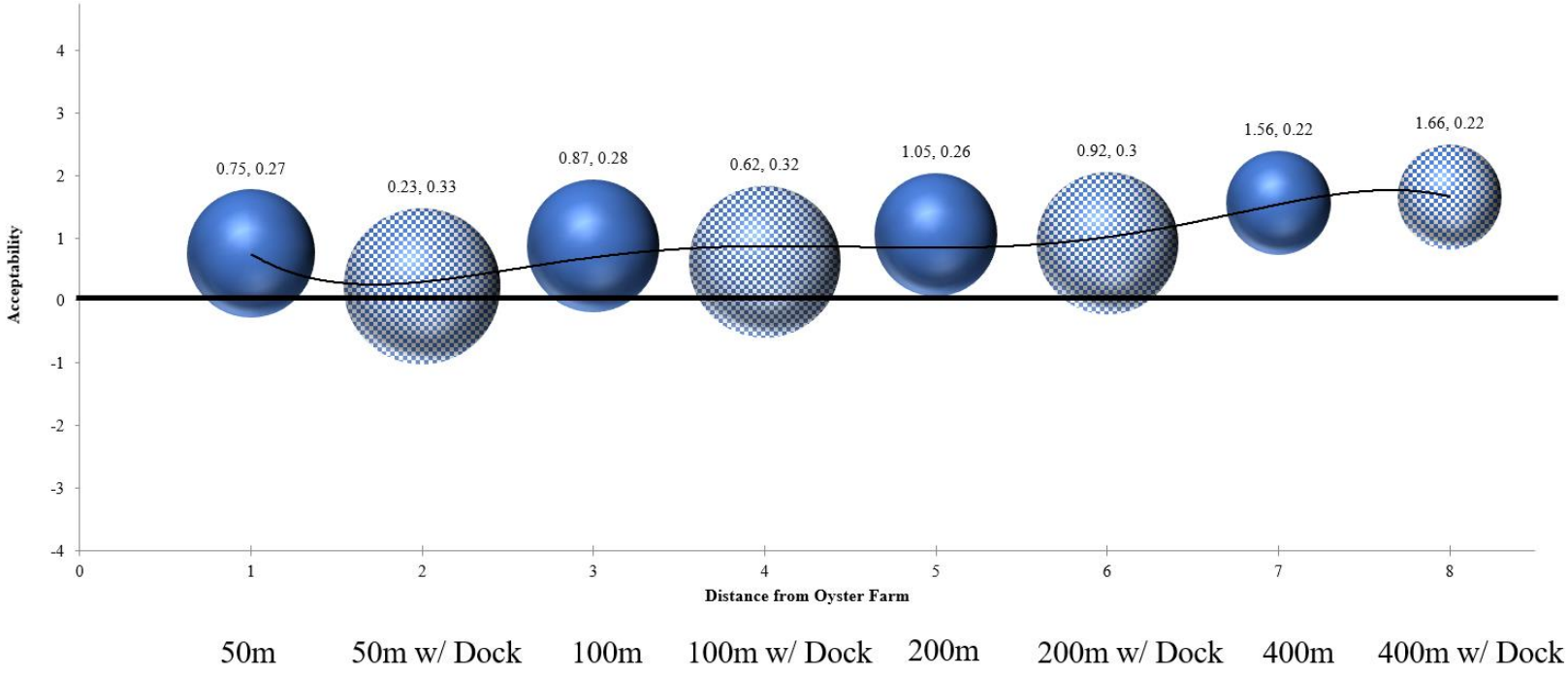


Figure 3. 5: Social norm-curve (Mean, PCI2) for Panel B, acceptability of potential oyster farm size in SC displayed in 360° VR.

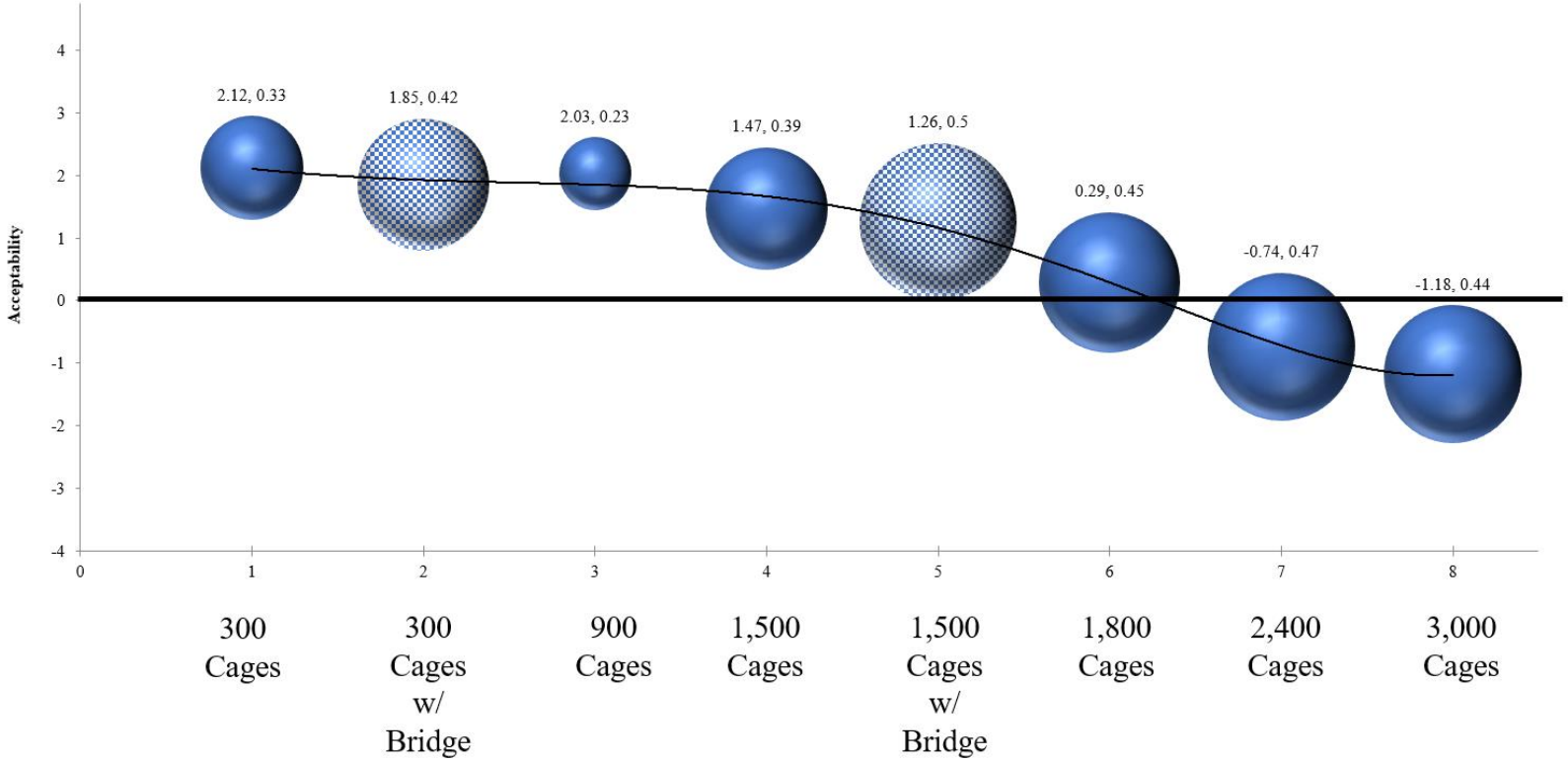
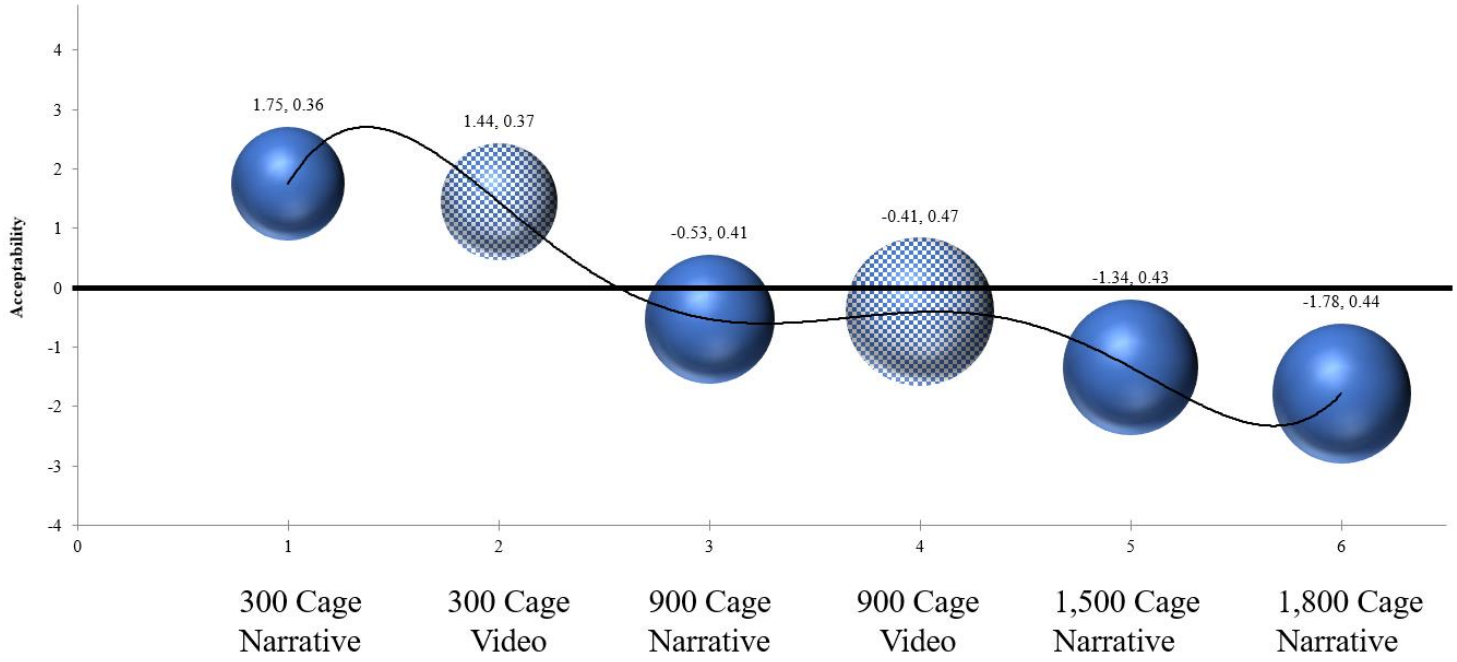


Figure 3. 6: Social norm-curve (Mean, PCI2) for Panel C, acceptability of potential oyster farm size in SC videos displayed in 360° VR and associated narratives.



CHAPTER 4

Visitor Awareness: The Conceptualization and Measurement of a Visitor Awareness Index

ABSTRACT

Awareness is a word that is often used when park and protected area (PPA) researchers and managers discuss the results of visitor studies and try to make sense of their findings. This chapter focuses on the ramifications of visitors' awareness of their being within a PPA's boundaries, awareness of its managing body, and awareness of the missions of that managing agency for that particular PPA. In this chapter, a Visitor Awareness Index (VAI) was conceptualized, measured, and then tested to determine if it influences perceptions of recreation impacts and attitudes towards management strategies and objectives. This chapter also investigates what factors might lead to higher 'visitor awareness' amongst visitors. Through the creation of four awareness groups based on visitors' cumulative mean VAI score and their type of self-reported awareness, the results show that there are modest differences between the groups. The results also suggest that many of the perceptions of their visit to the ACE Basin NERR (e.g., crowding) were not experienced any differently depending on their assigned awareness group. Although differences in place-based perceptions were not significant in this instance, further research should be conducted to explore if awareness may have influence on other aspects of visitor use management.

Key words: *Visitor Awareness Index (VAI), parks and protected areas (PPAs), management objectives, crowding, perceptions, awareness*

INTRODUCTION

What is awareness? Awareness is a word that park and protected area (PPA) researchers and managers often use to discuss the results of visitor studies and try to make sense of their findings. It is the authors' experience that managers and researchers alike often ask questions like, "*Are visitors aware that they are on protected lands?*", "*Are visitors aware that* [managing agency] *manages this area*?", and "*Are visitors aware of the rules and regulations in this place?*". In some cases, PPA researchers and managers think this information is so important that they include questions like these in their visitor surveys (Blotkamp et al., 2011; Cook & Le, 2015; Manni et al., 2013; Rogowski et al., 2022; Scruggs et al., 2022; Tuohy et al., 2022). The trouble is that the outcomes of these questions have not been examined for their implications beyond the "yes/no" or "*Are you aware that…*". Contained within the almost 300 pages of the U.S. National Park Service's Pool of Known Questions, which was last revised in October of 2019, only 14 questions address visitor awareness of either spatial whereabouts, management authority, or PPA policies or regulations (National Park Service, 2019).

Even if visitors are aware of the things that PPA managers would hope they are, what is the benefit of this awareness? It is possible that this type of awareness may influence visitors' perceptions, attitudes, and behaviors in ways that would make them more apt to match a PPA's purpose and management efforts. Unlike many of the major U.S. National Parks with well-defined entry points and brand recognition, lesser known PPAs or those with more porous boundaries may have visitors who do not know they are in a PPA or who's actions are unknowingly in conflict with the area's management efforts. These visitors might be less likely to notice their impacts, act unknowingly

against policies or management goals, or not support the protection or management of the area itself (Mascia, 2003). Many coastal protected areas (CPAs), like the ACE Basin National Estuarine Research Reserve (NERR), are good examples of locations where a visitor may not know that they are in a protected area because of poor or inadequate signage to inform them of protected area boundaries and management regulations (Martin et al., 2015). Also, visitors may not know they are in a protected area because of their unfamiliarity with the area they are visiting (i.e., out-of-town visitors and tourists) (Cook & Le, 2015; Porter & Wescott, 2004).

This chapter focuses on the ramifications of visitors' awareness of being within a PPA's boundaries, awareness of its managing body, and awareness of the mission of that managing agency for that PPA. In this study, a Visitor Awareness Index (VAI) was be conceptualized, measured, and then tested to determine if it influences perceptions of recreation impacts and attitudes towards management strategies and objectives. This chapter also investigated what factors might lead to higher *visitor awareness* amongst visitors. For example, is *visit awareness* related to past use history, recreation specialization, place attachment, or use activities or locations?

A deliberate study of visitor awareness is something that has been lacking in the scientific literature, despite its commonplace consideration in visitor studies and management. The implications of understanding *visitor awareness* could be widespread and eventually lead to more informed visitors, more effective management, and more positive outcomes for a visitor to a PPA.

Research Questions

This chapter conceptualizes and measures visitor awareness through the creation of a Visitor Awareness Index (VAI) for PPAs by answering the following research questions:

1. What dependent variables constitute a holistic approach to measuring visitor awareness?
2. Based on a Visitor Awareness Index score:
    a. What types of visitors are more aware than others?
    b. How does visitor awareness influence place-based perceptions (i.e., how crowding is felt among visitors)?
    c. What management actions (i.e., access to parking, interactions with staff, and educational programing) can promote visitor awareness?

LITERATURE REVIEW

What is awareness?

To create an index to measure visitor awareness, it is important to define what is meant by awareness. To define 'awareness' you first must explore the concept of 'consciousness'. As Tulving (1993, p.283) states, "Consciousness as an object of intellectual curiosity is the philosopher's joy and the scientist's nightmare." Trying to define awareness, let alone consciousness, has been a fundamental question asked by those ranging from philosophers, neurobiologists, and even consumer psychologists (Chartrand, 2005; Clifford et al., 2006; Koch, 2004). This task is made even more complicated when words like 'knowledge', 'familiarity' and other synonyms are used in place of 'awareness' within the literature (Lee et al., 2002).

Several studies have explored the relationship between consciousness and awareness and tried to distinguish the differences between the two (Block, 1995; Lamme, 2003; Tulving, 1995). In some cases, however, researchers found that consciousness and awareness are either used interchangeably with other synonyms (Koch, 2004; Lee et al., 2002; Spotts & Stynes, 1985), distinguished merely by "consciousness [being] the general capacity for having subjective experiences, whereas awareness refers to the particular exercise of that capacity" (Tulving, 1995, p. 295), or combined into the concept of 'conscious awareness' (Block, 1995; Chartrand, 2005; Lau & Rosenthal, 2011). Taking these views into account and for the purposes of this study, the authors would like to define 'awareness' as *having or showing realization, perception, or knowledge* (Merriam-Webster, 2022) while using the conceptualization model of Spotts & Stynes (1985) for 'familiarity with a recreation area' as a guide (Figure 4.1).

Geographic awareness

A key factor in the overall awareness of a visitor to PPAs is their understanding of the physical world and their position within it. Spatial cognition, or geographic awareness, has been studied in several fields and disciplines (e.g., cognitive development, behavioral geography, environmental psychology) to develop a conceptual foundation of geographic awareness in large-scale environments (Klippel, et al., 2010). This framework states that humans develop spatial knowledge three different ways: landmark knowledge, route knowledge, and survey knowledge (Hart & Moore, 1973; Moore, 1979; Seigel & White, 1975). Landmark knowledge, the quickest spatial knowledge acquired, is defined as "… discrete units that do not in themselves contain spatial information, other than the local spatial information implied by recognizable pattern." (Montello, 1998, p.144). In

other words, landmark knowledge is being able to recognize a salient entity within an environment. For example, it may be recognizing a geographic formation or tree as a waypoint.

Route knowledge refers to the ability to make connections between landmarks and the order in which landmarks present themselves while moving within an environment (Montello, 1998; Seigel & White, 1974). Once route knowledge is created and a *route* is taken repeatedly, survey knowledge is constructed. Survey knowledge is the ability to assign distance to the spaces between landmarks and to evolve past "choice-point" decisions (e.g., "at Landmark A, turn left, and continue until you reach Landmark B, then turn right" and so on; Montello, 1998). Survey knowledge also allows for the conscious creation of new routes, shortcuts, and detours when traveling between two points within an environment (Klippel et al, 2010). This concept can be used to understand how geographic awareness is created and how it can develop over time. In the context of PPA management, it could be hypothesized that geographic awareness is an important building block in how visitors and potential visitors interact and recreate within PPAs by effecting recreation activity choice, experience expectations, or visitor safety.

Awareness of managing body and mission

Another important factor in PPA visitor awareness is if visitors know who is managing the land that they are recreating on and the missions of that PPA. It was stated earlier that PPA managers are continually seeking information about visitors' awareness of their agency, specific regulations, and management objectives. This type of awareness could be thought of as a form of brand awareness. Brand awareness is the

ability for customers to identify a brand under different conditions (Lee, 2002). It is also thought that an individual's brand awareness can be characterized by both the depth and breadth of their awareness (Keller, 2003). The depth of brand awareness refers to the ability of the brand to come to the mind of the consumer, while the breadth of brand awareness describes the range of outcomes after that brands come to mind (Keller, 2003). These outcomes can be emotional, both positive and negative, or consumptive (e.g., choosing to interact or purchase that brand). To put this in the context of PPAs, the depth of brand awareness is represented by if the visitor can identify the name of the PPA they are recreating in, designation (e.g., park, historical site, wildlife management area, marine protected area), the managing body (e.g., National Park Service, National Oceanic and Atmospheric Administration, USDA Forest Service, individual state agencies), and ultimately the mission or regulations of that PPA. Breadth of brand awareness could be considered the motivations for why visitors chose to recreate in that PPA or not and the decisions made about the planning of their visit.

Although PPA researchers and managers discuss whether visitors possess *awareness* during informal conversations and while discussing the results of visitor studies, there is a lack of literature examining whether this *awareness* matters. Even though researchers may include *awareness*-type questions in their studies, often under the direction of PPA managers, little analysis is done with these results (Blotkamp et al., 2011; Cook & Le, 2015; Manni et al., 2013; Rogowski et al., 2022; Scruggs et al., 2022). Two studies conducted collectively by Old Dominion University, Kansas State University, and Clemson University at National Park sites (Rogowski et al., 2022; Scruggs et al., 2022) and one conducted by University of Idaho (Blotkamp et al., 2011)

only address awareness by asking "*Prior to your visit, were you aware that* [PPA name] *is managed by the National Park Service (NPS)?*" After reporting descriptive statistics, the authors offer no further analysis of why this awareness might matter. Another study conducted by University of Idaho (Manni et al., 2013) however, did expand on their look into visitor awareness by asking the following questions in a visitor survey: "*Prior to your visit, was your personal group aware that a recreational area called* [PPA] *existed*?", "*Prior to receiving this questionnaire, was your personal group aware that* [PPA] *is a unit of the National Park Service?*", and "*Prior to receiving this questionnaire, was your personal group aware that* [PPA] *is a part of the National Wild & Scenic Rivers Systems?"* Again, no further analysis was conducted as to why this visitor awareness might matter for the purposes of visitor use management.

The study conducted by Cook and Lee (2015) did, however, attempt to address the question of *what visitors might be more aware than others* by comparing visitors' (tourists) place of residence and seasonality (Summer vs Fall) to see if they influenced how aware visitors might be. The results of this research found that Fall visitors expressed more familiarity with the PPA's purpose and mission, recreation opportunities, rules and regulation, and the PPA's geographic layout when compared to both summer visitors and local residents. It was also found that summer visitors were the least aware group overall. Even though this study developed more insight about who may be more aware than others, it still does not attribute this awareness to any actions or outcomes.

One such study, though, does attempt to make the connection between level of visitor awareness and management outcomes. Tuohy et al. (2022) conducted a survey of 169 visitors to the Ningaloo Marine Park (NMP) in Australia to determine their

knowledge of who managed NMP, NMP's designation as a marine protected area (MPA), and the marine zoning regulations and their access to information about them. The results of this study found that most visitors to NMP did not self-report as having strong awareness of the primary management authority at NMP nor having awareness of the specific regulations attributed to NMP's MPA status. The authors then attempted to make the case that visitors' level of awareness is directly linked to improving decision-makers' ability to maximize their management goals socially, economically, and ecologically. The authors argue that lack of awareness can be attributed to lower voluntary compliance with management regulations, misunderstanding of policies, and could eventually lead to visitors' mistrust of managing authorities.

There are a few cases that have attempted to explore the concept of 'park awareness' and determine what attributes may contribute to this phenomenon. Three case studies investigated 'park awareness' in urban parks (Lee et al., 2002; Spotts & Stynes, 1984, 1985). The Spotts and Stynes (1984, 1985) articles explored what characteristics of both visitors and parks attributed to higher park awareness. Park awareness, in these studies, was measured by the percent of participants that could recall the name of a park, locate the park on a map, and identify the facilities that each park offers. The 1984 study revealed that the distance between a park and a visitor's home had a negative correlation when it came to their awareness. Also, parks that were older and displayed more development (percent of park's acreage in amenities) had a positive correlation with an individual's park awareness. Spotts and Stynes' study in 1985 took the results from the previous study and developed a conceptualization of park awareness, also called 'familiarity' by the authors (Figure 4.1). This conceptualization took the form of a

continuum which separated the aware from the unaware, those who may possess awareness of a recreation area but have no real knowledge about that area, and finally, the degree of awareness based on the amount of knowledge a visitor has about that recreation area.

Lee et al. in 2002 attempted to advance these works to assess how information use and sources may contribute to park visitor awareness levels in urban parks. This study focused on what information sources park visitors used to become aware and found that there were several relationships between park awareness and socio-demographic characteristics. Lee et al. (2002) found that all the socio-demographics tested (i.e., ethnic group, age, education, income, and household having a child under 18 years old) showed significant association with awareness level. The only exception to these results was gender, which showed an even distribution of awareness among male and female participants.

The United Nations Educational, Scientific, & Cultural Organization (UNESCO) has also conducted a few studies attempting to measure visitors' awareness of World Heritage (WH) site designation and the implications of this awareness (Dewar et al., 2012; King & Halpenny, 2014; Ryan & Silvanto, 2009; Wang & Yuan, 2020; Yan & Morrison, 2008). These studies investigated different aspects of *awareness* including how aware visitors were that they were in a WH designated site, if visitors could recognize the WH symbol and knew its significance, and whether WH designation influenced visitors' decisions to visit the area or the purpose of their visit. Findings from these studies included the presence of a relationship between awareness of WH designation and the purpose of the visit (Yan & Morrison, 2008). Specifically, visitors

who were more aware of the WH designation chose to participate in more cultural experiences compared to physical recreation activities (e.g., climbing). Findings also included that visitors who were aware had higher expectations for their visit compared to those who were not aware (Dewar et al., 2012; Yan & Morrison, 2008). The final finding that is pertinent is that PPAs were more apt to promote their local management authority or designation compared to the WH and UNESCO (King & Halpenny, 2014; Ryan & Silvanto, 2009).

By investigating these types of awareness (i.e., geographic, purpose, and managing body), the authors of this study were able to create a series of four questions to measure *visitor awareness* and to determine what managerial benefits might be reflected by this awareness.

METHODS

Site Description

The ACE Basin NERR is a nearly 100,000-acre protected estuary located in Beaufort, Colleton, and Charleston Counties in southeast South Carolina (Figure 4.2). The ACE Basin NERR, officially placed under local, state, and federal protection in 1992, is home to a network of coastal environments including saltwater and brackish-water marshes, maritime forest, and upland pine and bottomland hardwood forests. Because of the number of unique habitats within ACE Basin NERR, the reserve is considered one of the most ecologically diverse locations along the U.S. Atlantic Coast, which according to the reserve, creates unique recreational opportunities found in few other public lands and waterways within the United States (Maier, 2010).

Conceptual Model for VAI in PPAs

Based on the ideas and concepts presented in the literature review, the authors constructed a conceptual model to display the hypothesis of this study (Figure 4.3). Four variables were chosen to create the VAI based on different types of awareness that were consistent with the questions contained within the U.S. National Park Service's Pool of Known Questions (National Park Service, 2019). The four *Visitor Awareness Characteristics* go as follows: *PPA Name with associated designation* (*i*1), *Mission Statement* (*i*2), *Management Authority* (*i*3), and *PPA Geographic Boundary* (*i*4). Based on visitor's self-reported awareness of the four characteristics, the scores could then be combined to form a cumulative VAI score, determining an individual visitor's awareness of a PPA. The idea is that this VAI score could then be used to predict themes in visitor characteristics (i.e., past use history, activity type, home proximity to PPA, mode of transportation, and locations visited) or could determine how visitors cooperate with specific management objectives (i.e., place-based perceptions of crowding). The authors also hypothesize that specific management actions may influence a visitor's VAI score like educational programing, adequate access to high-use areas, and staff interactions with visitors.

It should be noted that *Public/Political Support* and *Policy Compliance* are included in this model based on the literature reviewed but are not explicitly addressed in this study. These management objectives are outside the scope of this research but are included in Figure 4.3 and addressed later in the discussion and conclusion section of this chapter.

Visitor Surveys

A visitor survey was conducted to determine visitors' awareness level, baseline

use information, indicators and thresholds for the visitor experience, and visitor attitudes towards potential management alternatives. Specifically, surveys were collected from both front-country users and water-based users. Front-country users include swimmers, picnickers, land-based fishers, and visitors at developed sites or front-country attractions such as beaches, picnic areas, visitor centers, and roadside parking areas. Sampling areas for front-country users include the Edisto State Park Environmental Learning Center and Botany Bay Plantation Wildlife Management Area & Heritage Preserve (WMAHP). Water-based users include boaters, paddlers, coastal fishers, and water-based campers. Sampling areas for water-based users include Live Oak Public Boat Launch, Bennetts Point Public Boat Launch, Wimbee Public Boat Launch, Otter Island and Pine Island. Some areas cater to more than one of the user types above due to the dynamic nature of the ACE Basin NERR. Multiple user types were present at all of these locations during the sampling effort. Sampling efforts occurred by either tabling or roaming at survey sites on randomly selected days (stratified by weekday versus weekend) and asking visitors at each of the locations to complete a survey.

Sampling efforts occurred over 23 days during the Spring and Summer of 2022. In total, 369 surveys were completed with a response rate of 76%. Surveys were administered in-person through a combination of paper and electronic tablets using *Qualtrics*, an online survey software, to individuals who were 18 years of age or over and intercepted within the ACE Basin NERR boundary.

RESULTS

Visitor Awareness Index

Based on the review of literature about visitor's awareness and conversations with leading experts in the field of PPA management, four distinct types of awareness were identified and incorporated into the creation of a Visitor Awareness Index (VAI): *PPA Name with associated designation* (*i*1), *Mission Statement* (*i*2), *Management Authority* (*i*3), and *PPA Geographic Boundary* (*i*4). To determine an individual visitor's awareness, participants answered a series of questions that addressed each of the four variables that are associated with being aware of a particular PPA. Participants were asked to self-rate their level of awareness on a 5-point Likert-type scale from 0 (Not at all aware) to 4 (Completely aware) for each of the four variables.

Due to the latent nature of VAI, we conducted a factor analysis to determine if any of the variables in the VAI were more influential than others when it came to the sample population's VAI score (Table 4.2). The results from this test showed that internal consistency was relatively high with a Cronbach's alpha of 0.858 and a reliability coefficient of 0.859. The lack of variability between factor scores demonstrates that a cumulative scoring approach can be used. Each of the items possessed a factor score of over 0.7 with a $X^2(2, 364) = 18.23$, $p<0.001$ meaning each of the items' scores could be combined, creating a cumulative score from 0 to 16, for each individual participant.

Through an iterative process of cluster analysis which consisted of expert review and visual inspection, a K-means cluster analysis using 3-5 group solutions was applied. This resulted is the use of a four-factor solution for dividing the sample as it was the strongest statistically and conceptually (Figure 4.4). Cluster analysis was chosen for its ability to decrease the amount of influential overlap our visitor characteristics may have amongst each other (MacQueen, 1967; Rendón, 2011). This process found natural

groupings of VAI scores among the sample. This choice allowed the researchers to create four distinct awareness groups within our sample based on patterns in participant's self-reported awareness on individual items and their cumulative mean VAI scores. It should be noted that the cluster analysis did not evenly distribute the sample into each of the four awareness groups as the distinctions were created based on the type of awareness displayed and not on their cumulative VAI mean score. This resulted in each awareness group having a different proportion of our entire sample. It should be kept in mind while visually inspecting the figures in this chapter that even though there might be visually significant differences in the figures, the proportion of the sample in each awareness group limits the strength of that significance.

Group 1: Unaware

The first group to emerge from our cluster analysis is the *Unaware* group, which accounted for 29% of our sample (Figure 4.4). Those who were identified as *Unaware* possessed a mean self-reported awareness score of 0 for each of the four items within the VAI with 42% self-identifying as male, 57% self-identifying as female and 1% self-reporting as other. The average age for the members of this group was 45 years old with 47% of them reporting household income of less than $100,000 annually. Approximately, 69% of individuals in this group possessed at least a four-year degree and live within a mean driving time of 4 hours and 14 minutes to the ACE Basin NERR. This group visited the ACE Basin NERR for an average of 1.42 days within the last month (30 days) before taking the survey and an average of 2.53 days over the previous year (12 months).

Group 2: Aware

The second group to emerge from our cluster analysis is the *Aware* group, which accounted for 35% of our sample, our largest group (Figure 4.5). Those who were identified as *Aware* possessed a mean self-reported awareness scores of *i*1= 4, *i*2= 4, *i*3= 3 and *i*4= 3 for each of the four items within the VAI with an overall mean VAI of 14 out of 16. There was an even gender split amongst this group with 50% self-identifying as male, 50% self-identifying as female. The average age for the members of this group was 49 years old with 54% of them reporting household income of less than $100,000 annually. Approximately, 62% of individuals in this group possessed at least a four-year degree and live within a mean driving time of 3 hours and 24 minutes to the ACE Basin NERR. This group visited the ACE Basin NERR for an average of 3.56 days within the last month (30 days) before taking the survey and an average of 16.86 days over the previous year (12 months).

Group 3: Name_Purpose

The third group to emerge from our cluster analysis is the *Name_Purpose* group, which accounted for 22% of our sample (Figure 4.5). Those who were identified as *Name_Purpose* possessed a mean self-reported awareness scores higher on the first two items, *i*1= 3 and *i*2= 3, but lower on the last two items, *i*3= 2 and *i*4= 2, with and overall mean VAI score of 10 out of 16. Gender distribution for this group was 42% self-identifying as male, 57% self-identifying as female and 1% self-reporting as other. The average age for the members of this group was 52 years old with 47% of them reporting household income of less than $100,000 annually. Approximately, 69% of individuals in this group possessed at least a four-year degree and live within a mean driving time of 4

hours and 25 minutes to the ACE Basin NERR. This group visited the ACE Basin NERR for an average of 3.31 days within the last month (30 days) before taking the survey and an average of 12.34 days over the previous year (12 months).

Group 4: MGMT_Boundary

The fourth group to emerge from our cluster analysis is the *MGMT_Boundary* group, which accounted for 13% of our sample, our smallest group (Figure 4.5). Those who were identified as *MGMT_Boundary* possessed a mean self-reported awareness scores lower on the first two items, $i1 = 1$ and $i2 = 1$, but higher on the last two items, $i3 = 2$ and $i4 = 3$, with and overall mean VAI score of 7 out of 16. Gender distribution for this group was 43% self-identifying as male, 57% self-identifying as female. The average age for the members of this group was 44 years old with 45% of them reporting household income of less than $100,000 annually. Approximately, 60% of individuals in this group possessed at least a four-year degree and live within a mean driving time of 3 hours and 29 minutes to the ACE Basin NERR. This group visited the ACE Basin NERR for an average of 2.51 days within the last month (30 days) before taking the survey and an average of 11.5 days over the previous year (12 months).

What visitors are more aware than others?

Even though the process of cluster analysis was able to divide our sample into four awareness groups based on VAI score, there were relatively few instances where there were statistically significant demographic differences between each of the four awareness groups. Based on the demographic profiles created for each awareness group, as described above, age differences between *Unaware* and *Name_Purpose* was found to be marginally significant ($p=0.047$). There were also significant differences found when

we looked at respondents' proximity (i.e., calculated driving time via *CDXZipStream™)* to the ACE Basin NERR based on their reported zip code of residence. After the removal of six outliers, no more than 3 in one awareness group, both *Unaware* and *Name_Purpose* groups had significantly longer driving time compared to the *Aware* group ($F(3, 309)=3.72$, $p=0.012$).

Some differences exist when past use history is examined. *Unaware* and *MGMT_Boundary* groups contained significantly more first-time users, when compared to *Aware* group ($X^2(3, 358)=24.64$, $p < 0.001$). For the number of days visiting the ACE Basin NERR over the past 30 days, there were significant differences between the *Unaware* and *Aware* groups and the *Unaware* and *Name_Purpose* groups ($F(3,333)=4.48$, $p< 0.01$) with *Unaware* visiting less. Differences were also found when we expanded past use history to over the last 12 months between the *Unaware* and *Aware* groups ($F(3,330)=3.12$, $p<0.01$).

Few differences were found between awareness groups when it came to the areas in which they primarily visited (i.e., Frontcountry vs Backcountry). The only marginally significant difference found was between *Unaware* and *Aware* groups ($X^2(12, 332) =24.45$, $p = 0.018$; Figure 4.5) with the Aware group being more prone to backcountry areas. The distinctions between Frontcountry and Backcountry were based on ACE Basin NERR managers' suggestions of categorization for each of the listed areas contained within the survey. Comparing primary modes of transportation and activity types for each of the awareness groups produced no statistical differences among respondents ($X^2(31, 465) =11.92$, $p = 0.48$ and $X^2(45, 338) =45.54$, $p = 0.45$, respectively; Figures 4.6 and 4.7).

Does visitor awareness influence how crowding is felt among visitors?

Researchers wanted to determine if VAI influenced place-based perception (i.e., crowding) among the sample. When asked how crowded respondents felt at Botany Bay WMAHP on a 9-point scale from -4 (Extremely Crowded) to +4 (Not Crowded), there were no differences in mean responses among the four awareness groups ($F(3,340)=1.33$, $p=0.26$;Figure 4.8). There were also no differences between awareness groups found when we asked about the acceptability of encounter rates per hour at Botany Bay WMAHP (Table 4.3). A Potential for Conflict Index (PCI2) score for each encounter rate is also displayed with each acceptability mean to help understand the amount of consensus about the social acceptability of that condition (Manfredo, et al., 2003). PCI2 is a scale that ranges from 0 to 1 with scores closer to zero indicating more consensus among respondents while scores closer to one indicating less consensus. All PCI2 scores for each encounter rate and each awareness group never rose above 0.43 indicating that there is relative consensus among our sample. No significance difference between awareness groups was found for mean responses regarding how encountering too many people at Botany Bay WMAHP influenced the quality of a person's experience ($F(3,254) =1.75$, $p=0.17$; Figure 4.9).

What management actions can influence visitor awareness?

Researchers also wanted to determine if management actions might influence VAI score. When respondents were asked whether or not they have ever participated in an educational program at the ACE Basin NERR, the only significant difference between awareness groups was between the *Aware* and *Unaware* groups with the *Aware* group participating more ($F(3,304) =2.85$, $p=0.04$; Figure 4.10). Researchers did not observe

any differences between awareness groups when respondents were asked about how influential adequate parking at high-use attraction sites ($F(3,125)=0.6$, $p=0.62$), experiencing adequate and helpful staff ($F(3,172)=0.09$, $p=0.97$), and interesting educational programing ($F(3,133)=0.28$, $p=0.84$) were during their current visit to the ACE Basin NERR.

DISSCUSSION

Measurement and Segmentation

Based on the literature review, exchanges with experts in the field, and based on the types of questions contained in the NPS Pool of Known Questions (2019), the authors determined that PPA managers tend to be interested in four distinct themes of awareness. These themes were identified and incorporated into the creation of the VAI: *PPA Name with associated designation* (*i*1), *Mission Statement* (*i*2), *Management Authority* (*i*3), and *PPA Geographic Boundary* (*i*4). To determine an individual visitor's awareness, participants answered the series of questions that addressed each of these four variables. Participants were asked to self-rate their level of awareness on a 5-point Likert-type scale from 0 (Not at all aware) to 4 (Completely aware) for each of the four variables. The combination of these scores constituted each visitor's overall VAI score. Visitors were then divided into an awareness group which would cluster visitors who scored similarly on each of the four VAI questions to answer the research questions.

VAI and Visitor Characteristics

Once the VAI was developed and measured, it was important to see if there were any differences among the awareness groups created through the cluster analysis. Some

of these differences are intuitive, such as visitor's home proximity to the ACE Basin NERR. Those who were either in the *Aware* or *MGMT_Boundary* groups reported being within closer proximity to the reserve than the other two groups by almost an hour of driving time. This seems to be a logical outcome and corresponds with the findings of Spotts and Stynes (1984, 1985) because those who express being *Aware* would have likely more exposure to information about the reserve as a whole and those who are more aware of the management authority and the boundary of the reserve would likely be those who share a geographic region with a PPA. This also makes sense when we look at first time users. Even though the *Aware* group was found to have significantly more repeat users when compared to the *Unaware* and *MGMT_Boundary* awareness groups, the *MGMT_Boundary*'s proximity to the reserve could be a reason why this group expresses a higher cumulative VAI mean score compared to the *Unaware* group. In other words, the *MGMT_Boundary*'s proximity to the reserve would increase their likelihood of being exposed to information about the reserve as a whole and those who are more aware of the management authority and the boundary of the reserve would likely be those who share a geographic region with a PPA.

Another intuitive result that was found is that past use history was also influential in cumulative mean VAI score. Both the *Aware* and *Name_Purpose* groups had significantly more visitation to the ACE Basin NERR over the past month compared to the *Unaware* group. The *Aware* group also reported having over 14 more days of visitation over the past 12 months compared to the *Unaware* group. These results also exemplify that the likelihood of being exposed to more place-based information is influential in having a higher cumulative mean VAI score. More simply put, the more

you visit and utilize a PPA, the more aware of a PPA you will be. These results are also reflective of the findings by Moorthy et al. (1997) that found that past experiences influence the amount of knowledge, or experience, one has on a particular place or brand. What was interesting, however, was that none of the awareness groups possessed any other sociodemographic differences. These findings are the opposite of those by Lee et al. (2002) where they found that sociodemographic variables held some association to level of awareness. These differences could be a result of the type of PPA that each study is researching. Lee et al. (2002) focused on urban parks in a metropolitan area whereas this study focuses on a much larger, more rural coastal location. The authors hypothesize that this could be reflective of the homogeneous populations found in rural recreation settings, which ultimately made up our sample.

The type of location within the ACE Basin NERR where visitors recreated was also reflective in their awareness group. Those visitors that were categorized in the *Aware* group reported utilizing backcountry locations as their primary area visited more than any other awareness group (Figure 4.5). This would coincide with the results found about primary mode of transportation. It was found that those who had some form of awareness were more prone to utilize motorized boats than those who were *Unaware* (Figure 4.6). Visitors who are more aware of a PPA and the boundary of that area are more likely to explore the backcountry areas of that PPA. This relates to the geographic concept mentioned earlier in this chapter. Montello (1998) states that differences in geographic awareness and cognition are, in part, due to the differing exposure to a place or area and the differing types of ways individuals are exposed to them. In the case of the ACE Basin NERR, the primary way to access those areas is by boat. It also makes sense

that those who are closer in proximity to the ACE Basin NERR would utilize boats more than those further away as hauling watercraft may not be as desirable the further away you are from your primary water access point.

One limitation to our results and how reflective VAI is to visitor characteristic is the time of year that we surveyed our sample. This is because researchers did not see any differences among the awareness groups and their primary activity type (Figure 4.7). By sampling in the Spring and Summer, we unintendedly eliminated some of the activity types that we would hypothesize as being more prone to visitors that are more aware. Many of the consumptive activities that are available to visitors at the ACE Basin NERR (i.e., hunting and trapping, oyster harvesting, and overnight camping) were all relatively low or nonexistent among our sample. This is due to the local rules and regulations on harvesting seasons, take limits, and camping seasons set by either the ACE Basin NERR or SCDNR. Hunting and trapping in southeast South Carolina is primarily a Fall and Winter activity with seasons opening between September through March. Oyster harvesting does, however, extend from October through May but again, none of our sample responded with that being their primary activity. This could very well have been the main reason why reports of these activity types were low or nonexistent among our sample. It should also be noted that overnight camping on Otter Island, home to 6 of the 9 primitive camping sites, is closed to camping from March 13th through October 15th, during the primary nesting seasons of many shorebirds and sea turtles. Managers for this area have only given out an average of 16 permits per year since data began being collected in 2002. The other three campsites are on S. Fenwick Island and are open year-round, except for during the archery season, October 1st – 10th, but only receive an

average of 13 permits per year since 2018, the earliest known records. These low visitor totals make it difficult to reach these users without specific targeted efforts which could be incorporated into future iterations of this research.

VAI and Place-based Perceptions

As a function of visitor awareness, researchers wanted to determine whether VAI influenced how crowding was perceived within the ACE Basin NERR. It was hypothesized that those who expressed more awareness and were in either the *Aware*, *Name_Purpose*, or the *MGMT_Boundary* groups would be more sensitive to crowding due to their awareness of the area's mission statement. The mission states that the management objectives of the ACE Basin NERR are to "*Sustain the ecological health of the ACE Basin's estuaries and provide natural areas for research, education, stewardship, and compatible human uses*". This, however, ended up not being the case for the sample as there were no differences in how crowding was perceived between any of the four awareness groups. These results reflect similar findings to Cribbs et al. (2020) where a shift in visitors' acceptability of increased use is possibly being observed. This study found that even though visitors experienced higher levels of use within the *Wilderness* section of a river compared to a non-wilderness section of the same river, that their acceptability of use was no different between the two. Even though the ACE Basin NERR is not designated as *Wilderness*, much of this area is quite remote and can be only accessed by boat. These conditions tend to simulate wilderness-like experiences (e.g., solitude) which could cause visitors to expect lower use levels, which in turn may make them more sensitive to crowding.

One limitation to this, however, is that the questions that were asked about crowding only focused on high-use areas (i.e., Botany Bay WMAHP). The authors hypothesize that the lack of differences in acceptability for crowding could be because Botany Bay WMAHP is the most popular area within the ACE Basin NERR. Visitors may be anticipating higher use levels when visiting this area and are expecting higher use levels compared to other locations within the reserve. It would be interesting if the same questions were asked for other, more infrequently used areas.

It should be noted, however that each of the four awareness groups had a mean score of no more than 1.5 on a scale from -4 to +4 (Figure 4.8). This could have management implications and suggests that there could be a crowding concern beginning to occur among the visitors to the Botany Bay WMAHP within the ACE Basin NERR. The results in Table 4.3 suggest that the current encounter rate of visitors at Botany Bay WMAHP is around 20 to 40 encounters per hour and that the threshold of acceptable conditions for crowding is somewhere between 40 and 80 encounters per hour. Figure 4.9 does suggest, however, that 70% of the visitors to Botany Bay WMAHP have not yet been affected by crowding. This could very well mean that the conditions that are currently being experienced at Botany Bay WMAHP are at a point where management might want to take action to preserve the quality of visitor experience while crowding is still within an acceptable condition.

Management actions that could influence VAI

When examining aspects of management that could possibly influence a visitor's awareness (i.e., access to parking, interactions with staff, and educational programing), it was discovered that the only influential action that drove VAI to increase was

participation in educational programing (Figure 4.10). The *Aware* group was the most apt to have participated in educational programing with 18% reporting having ever participated in one with *Name_Purpose* having 14% participation and *MGMT_Boundary* reporting 13% participation. Those who were in the *Unaware* group, however, only saw 4% participation in educational programing. This aligns with the findings of Stern et al. (2008) that indicates that participation in park educational programing had a positive influence on awareness. It is logical that those who are categorized as having some form of awareness, being placed in any awareness group other than *Unaware*, are more likely to have participated in an ACE Basin NERR educational program in the past. However, the influence educational programing had on the quality of experience was not significantly different between the four awareness groups. Similar results were found for the influence of adequate parking and interactions with staff on their visit quality. All visitors seemed to have similar encounters or perceptions of those encounters and no differences were found between awareness groups.

These results could point to a few things. Due to the influence of educational programing had on awareness, management may want to focus on how visitors are gathering information about the reserve. The relatively low participation numbers for educational programing are quite interesting. They show that even awareness groups with modest participation in educational programing saw a significant rise in VAI score compared to the *Unaware* group. This may be worth further examination by management. Management may want to review how they and their staff are advertising these programs and how often they are being conducted. It may also be wise for management to review their outreach programing so that they may educate visitors before

they visit the reserve. These combined efforts may maximize the influential power management may have on visitor awareness. If maximized, managers could begin to see the types of differences awareness was hypothesized to have on perceptions of crowding, along with influencing other management objectives that were included in the model presented in Figure 4.3 (i.e., public/political support and policy compliance).

CONCLUSION

This research focused on the ramifications of visitors' awareness of their being within a PPA's boundaries, awareness of its managing body, and awareness of the mission of that managing agency for that particular PPA. In this chapter, a VAI was conceptualized, measured, and then tested to determine if it could be a predictor of visitor characteristics and demographics, influenced place-based perceptions (i.e., crowding), and related to attitudes towards management strategies. It was found that outside of what we might hypothesize as intuitive differences among visitors within awareness groups (i.e., proximity to PPA, frequency of visitation, participation in educational programing) we saw relatively minimal differences among our sample. More differences may have been observed based on primary activity type but with the limitations of seasonality possibly influencing our results, we cannot assume that such differences are present. The results suggest that this current version of VAI may not be related to visitor characteristics among this sample.

Although the perceptions of crowding are not felt differently among those in different awareness groups, these results do suggest that managers are at a very interesting period in visitation. Even though self-reported awareness varies among our

sample, visitors are reporting having very similar experiences, particularly at Botany Bay WMAHP, the most popular attraction site within the ACE Basin NERR. Visitors of all types are nearing the normative threshold for crowding and have indicated where that point of minimal acceptability might be. This could very well be a time for management to develop strategies to maintain or improve the current conditions.

The implication of this research is that these results may dispel the notion that visitors' awareness matters. Even though researchers and managers of PPAs may think that it's a logical progression that the more aware a visitor is about an area, the more their attitudes and actions might change, in this case, we see little support for this among our sample. The authors of this chapter do, however, suggest that further research could be done to determine if VAI has any influence on other management objectives such as if those who are more aware are more publicly and politically supportive of a particular PPA or if VAI has any influence on rules or policy compliance. It could be hypothesized that the more aware visitors are, the more supportive and compliant they may be but as we can see from the results of this chapter, it might not be as simple as that. Also, in some cases, awareness may matter to the management agency of a PPA since their mission or their work might depend on a visitor being aware of the place that are visiting or the entity responsible for it. Overall, this research adds to the current knowledge base regarding visitor use management and how to better understand visitors to PPAs. This research addresses one of the more frequently asked questions between researchers and managers of "*Does awareness matter?"* and based on these results, we are left with more questions than answers.

REFERENCES

Blotkamp, A., Holmes, N. C., Littlejohn, M., Hollenhorst, S. J. (2011). *Delaware Water Gap National Recreation Area Visitor Study: Summer 2010*. Natural Resource Report NPS/NRSS/SSD/NRR—2011/620/107705. National Park Service, Fort Collins, Colorado.

Chartrand, T. L. (2005). The role of conscious awareness in consumer behavior. *Journal of Consumer Psychology*, 15(3), 203-210.

Clifford, C. W., Arabzadeh, E., & Harris, J. A. (2008). Getting technical about awareness. *Trends in cognitive sciences*, 12(2), 54-58.

Cook, P.S., and Le. Y. (2015). *Cape Lookout National Seashore visitor and resident studies: Fall 2013—Summer 2014*. Park Studies Unit, College of Natural Resources, University of Idaho, Moscow.

Cribbs, T. W., Sharp, R. L., Brownlee, M. T., Perry, E. E., & Fefer, J. (2020). In search of solitude: A case study of wilderness and non-wilderness river users. *International Journal of Wilderness*, 26(3), 72-87.

Dewar, K., Du Cros, H., & Li, W. (2012). The search for World Heritage brand awareness beyond the iconic heritage: A case study of the Historic Centre of Macao. *Journal of Heritage Tourism*, 7(4), 323-339.

Hart, R. A., & Moore, G. T. (1973). *The development of spatial cognition: A review*. Aldine Transaction.

Keller, K.L. (2003). *Strategic Brand Management: Building, Measuring, and Managing Brand Equity*. New Jersey: Prentice Hall.

King, L. M., & Halpenny, E. A. (2014). Communicating the World Heritage brand: visitor awareness of UNESCO's World Heritage symbol and the implications for sites, stakeholders and sustainable management. *Journal of Sustainable Tourism*, 22(5), 768-786.

Klippel, A., Hirtle, S., & Davies, C. (2010). You-are-here maps: Creating spatial awareness through map-like representations. *Spatial Cognition & Computation*, 10(2-3), 83-93.

Koch, C. (2004). *The quest for consciousness a neurobiological approach*. Roberts and Company Publishers

Lamme, V. A. (2003). Why visual attention and awareness are different. *Trends in cognitive sciences*, 7(1), 12-18.

Lau, H., & Rosenthal, D. (2011). Empirical support for higher-order theories of conscious awareness. *Trends in cognitive sciences*, 15(8), 365-373.

Lee, I., Floyd, M. F., & Shinew, K. J. (2002). The Relationship Between Information Use and Park Awareness: A Study of Urban Park Users. *Journal of Park & Recreation Administration*, 20(1).

Maier, P. (2010). *Ashepoo-Combahee-Edisto (ACE) Basin National Estuarine Research Reserve Management Plan 2011-2016*. South Carolina Department of Natural Resources, Charleston, SC.

Manni, M. F., Le, Y., and Hollenhorst, S. J. (2013). *Missouri National Recreational River visitor study: Summer 2012*. Natural Resource Report NPS/NRSS/EQD/NRR—2013/645. National Park Service, Fort Collins, Colorado.

Martin, C. L., Momtaz, S., Jordan, A., & Moltschaniwskyj, N. A. (2015). An assessment of the effectiveness of in-situ signage in multiple-use marine protected areas in providing information to different recreational users. *Marine Policy*, *56*, 78-85.

Mascia, M. B. (2003). The human dimension of coral reef marine protected areas: recent social science research and its policy implications. *Conservation biology*, 17(2), 630-632.

MacQueen, J. (1967). Some methods for classification and analysis of multivariate observations. In *Proceedings of the fifth Berkeley symposium on mathematical statistics and probability* (Vol. 1, No. 14, pp. 281-297).

Merriam-Webster, Incorporated. (2022). *The Merriam-Webster Dictionary*.

Montello, D. R. (1998). A new framework for understanding the acquisition. *Spatial and temporal reasoning in geographic information systems*, 143.

Moore, G. T. (1979). Knowing about environmental knowing: The current state of theory and research on environmental cognition. *Environment and behavior*, 11(1), 33-70.

Moorthy, S., Ratchford, B. T., & Talukdar, D. (1997). Consumer information search revisited: Theory and empirical analysis. *Journal of consumer research*, 23(4), 263-277.

National Park Service (2019). *Programmatic Clearance for NPS-Sponsored Public Surveys: Pool of Known Questions*. OMB report. Retrieved January 11, 2023, from https://omb.report/icr/201910-1024-002/doc/95528101

Porter, C., & Wescott, G. (2004). Recreational use of a marine protected area: Point Lonsdale, Victoria. *Australasian journal of environmental management*, 11(3), 201-211.

Rendón, E., Abundez, I., Arizmendi, A., & Quiroz, E. M. (2011). Internal versus external cluster validation indexes. *International Journal of computers and communications*, *5*(1), 27-34.

Rogowski, J., Fefer, J.P., Zajchowski, C.A.B., Henry, C., Scruggs, C., Sharp, R.L., & Brownlee, M.T.J. (2022). *Support visitor use management at Prince William Forest Park: A report based on multiple methods of visitor-based data collections*. Report delivered to management staff of Prince William Forest Park, Department of Interior, National Park Service. In fulfillment of agreement P19AC010771. Triangle, VA

Ryan, J., & Silvanto, S. (2009). The World Heritage List: The making and management of a brand. *Place Branding and Public Diplomacy*, 5(4), 290-300.

Scruggs, C., Zajchowski, C., Fefer, J., Henry, C., Sharp, R.L. & Brownlee, M.T.J. (2022). *Social science research to support visitor use management at Monocacy National Battlefield*. Report delivered to management staff at Monocacy National Battlefield, Department of Interior, National Park Service. In fulfillment of agreements P19AC000946 and P19AC010771.

Siegel, A. W., & White, S. H. (1975). The development of spatial representations of large-scale environments. *Advances in child development and behavior*, 10, 9-55.

Spotts, D. M., & Stynes, D. J. (1984). Public awareness and knowledge of urban parks: a case study. *Journal of Park and Recreation Administration*, 2(4), 1-12.

Spotts, D. M., & Stynes, D. J. (1985). Measuring the public's familiarity with recreation areas. *Journal of Leisure Research*, 17(4), 253-265.

Stern, M. J., Powell, R. B., & Ardoin, N. M. (2008). What difference does it make? Assessing outcomes from participation in a residential environmental education program. *The Journal of Environmental Education*, *39*(4), 31-43.

Tuohy, P., Cvitanovic, C., & Shellock, R. J. (2022). Understanding visitor awareness and knowledge of marine parks: Insights from the Ningaloo Coast, Australia. *Ocean & Coastal Management*, 227, 106282.

Wang, Z., & Yuan, B. (2020). Harmonizing the branding strategy of world natural heritage in China: visitors' awareness of the multiple brands of Wulingyuan, Zhangjiajie. *Geoheritage*, 12(2), 41.

Yan, C., & Morrison, A. M. (2008). The influence of visitors' awareness of world heritage listings: A case study of Huangshan, Xidi and Hongcun in southern Anhui, China. *Journal of Heritage Tourism*, 2(3), 184-195.

TABLES AND FIGURES

Table 4. 1: Factor Analysis for VAI

How aware are you that…	Mean	SD	Factor Score	Chi-Square	Comparative Fit Index	Root Mean-Square Residual	Cronbach's Alpha	Reliability Coefficient RHO
…You are visiting a location within the ACE BASIN National Estuarine Research Reserve? (*i*1)	3.28	1.69	0.798					
…The purpose of the ACE Basin NERR is to "*Sustain the ecological health of the ACE Basin's estuaries and provide natural areas for research, education, stewardship, and compatible human uses*"? (*i*2)	3.1	1.61	0.874	18.23	0.976	0.082	0.858	0.859
…The ACE Basin NERR is managed jointly by the South Carolina Department of Natural Resources (SCDNR) and the National Oceanic and Atmospheric Association (NOAA)? (*i*3)	2.65	1.6	0.708					
…That the boundary of the ACE Basin NERR is what is shown on the map provided? (*i*4)	2.86	1.62	0.72					

Table 4. 2: Acceptability of encounters per hour by VAI group

	Encounter Rate per Hour (M(PCI2))					
VAI Group	0	10	20	40	80	160
Unaware	2.27(0.15)	3.03(0.09)	2.29(0.17)	0.37(0.41)	-0.97(0.43)	-1.92(0.42)
Aware	2.52(0.15)	2.51(0.09)	1.94(0.14)	0.63(0.34)	-0.69(0.34)	-1.51(0.32)
Name_Purpose	2.51(0.16)	2.73(0.06)	1.83(0.15)	0.16(0.24)	-1.43(0.33)	-2.29(0.31)
MGMT_Boundary	2.45(0.32)	2.35(0.24)	1.72(0.25)	0.61(0.32)	-0.42(0.24)	-1.5(0.37)
	F(3,248)=0.12, p=0.95	F(3,237)=1.66, p=0.18	F(3,240)=0.91, p=0.44	F(3,231)=2.6, p=0.72	F(3,224)=1.29, p=0.28	F(3,219)=0.99, p=0.4

Figure 4. 1: A conceptualization of familiarity with a recreation area (Spotts & Stynes, 1985)

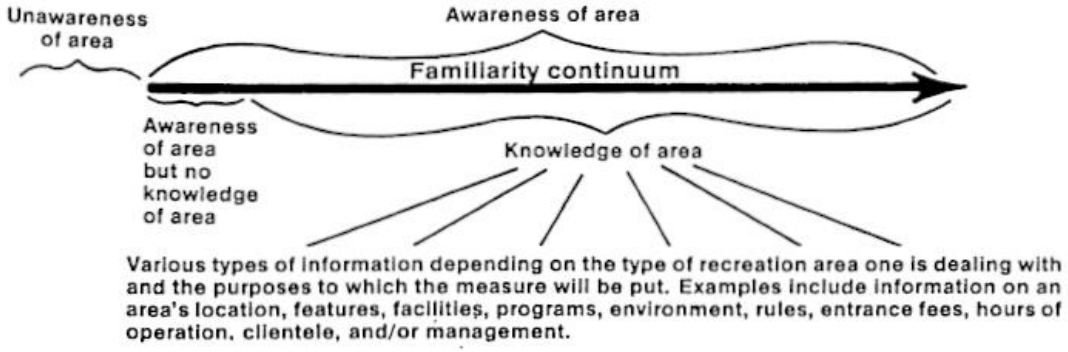


Figure 4. 2: Map of ACE Basin NERR

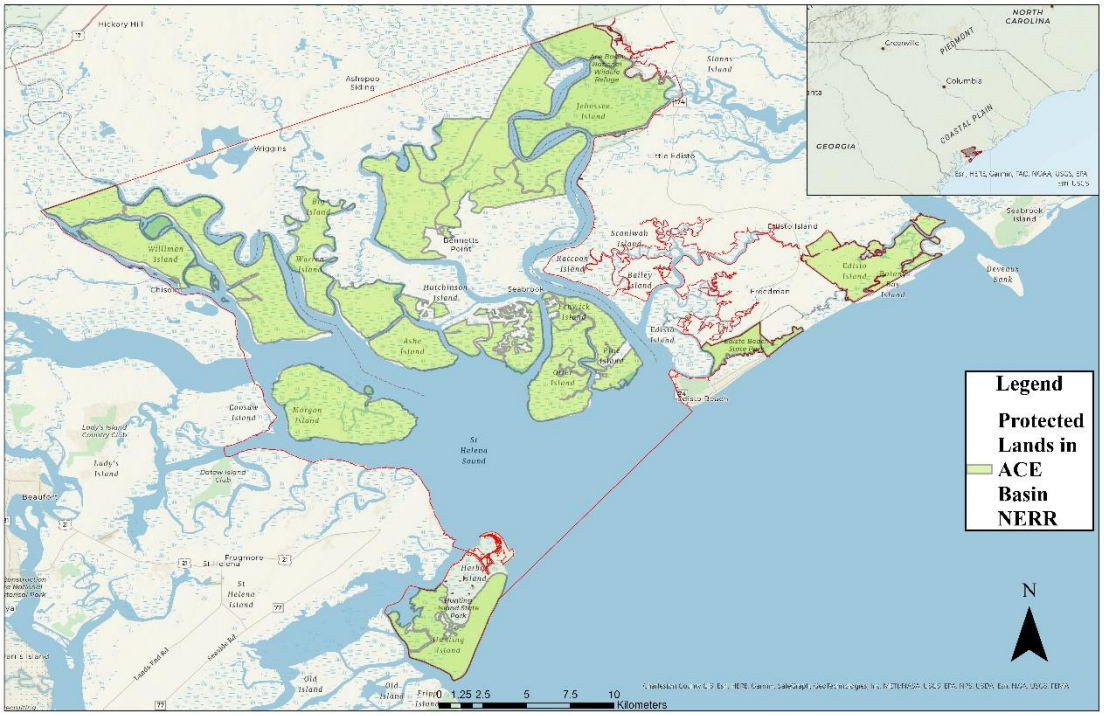


Figure 4. 3: Conceptual model of VAI for PPAs

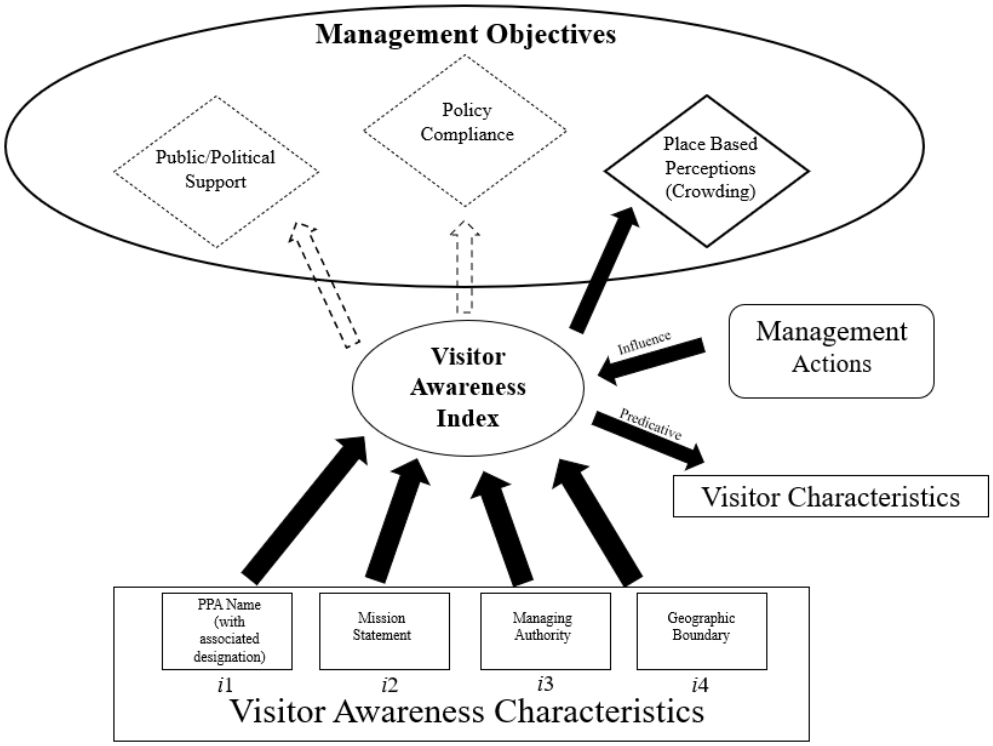


Figure 4. 4: Awareness Groups with corresponding VAI scores (% of sample in bubble)

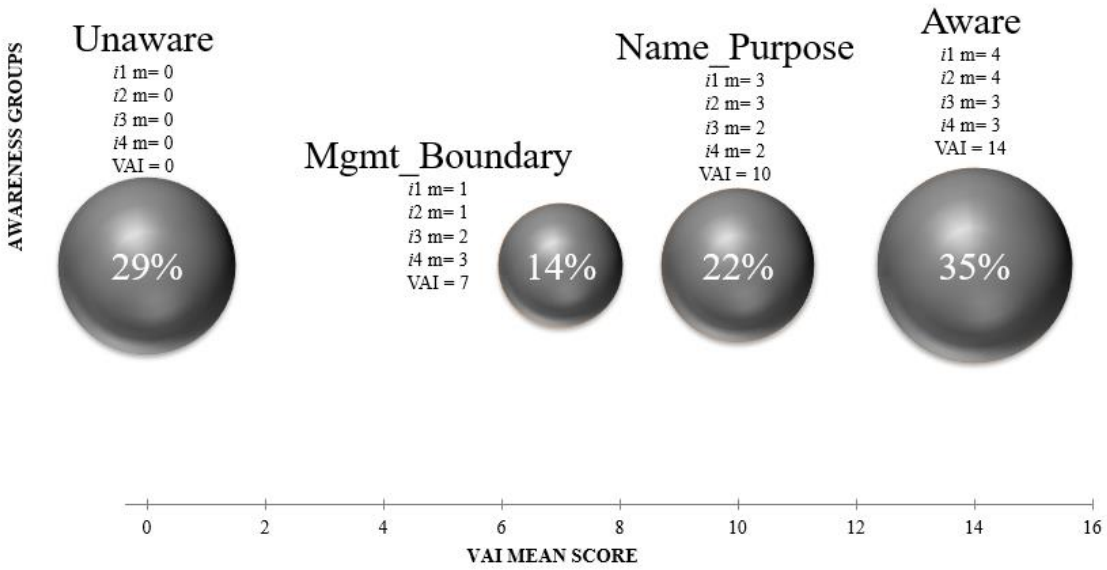


Figure 4. 5: Frontcountry vs Backcountry use by VAI Group

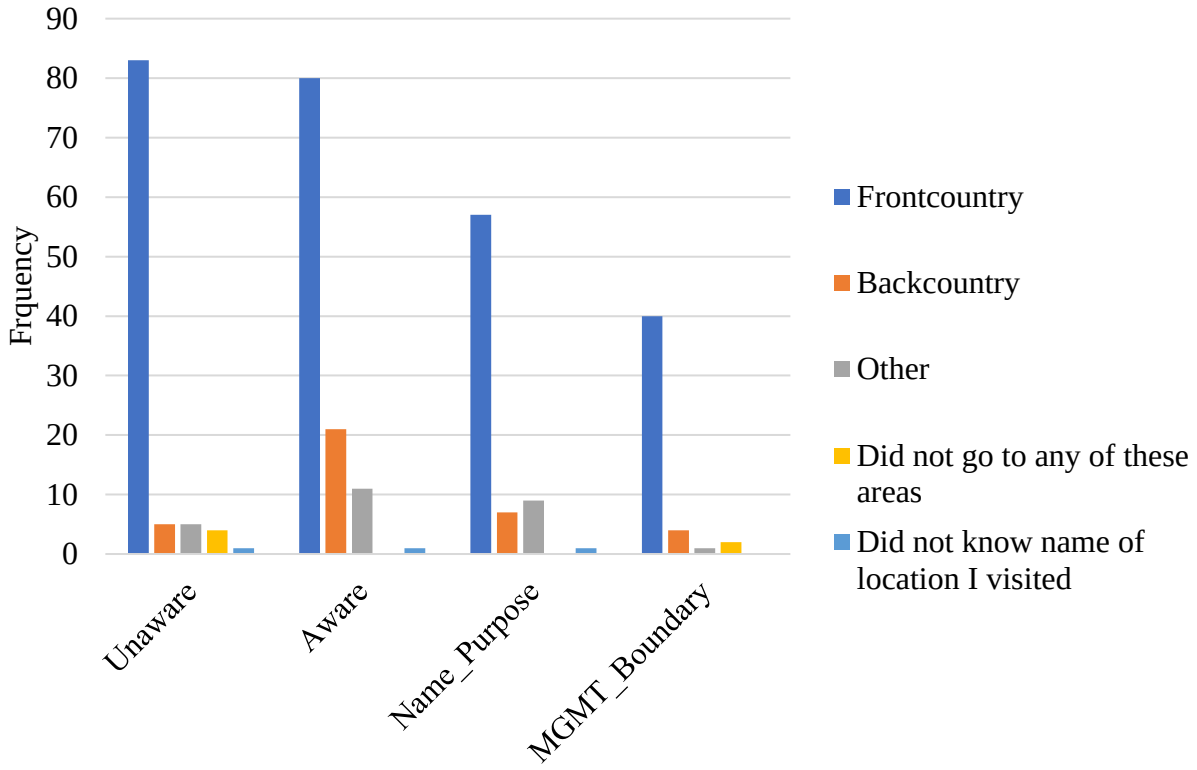


Figure 4. 6: Primary modes of travel by VAI Group

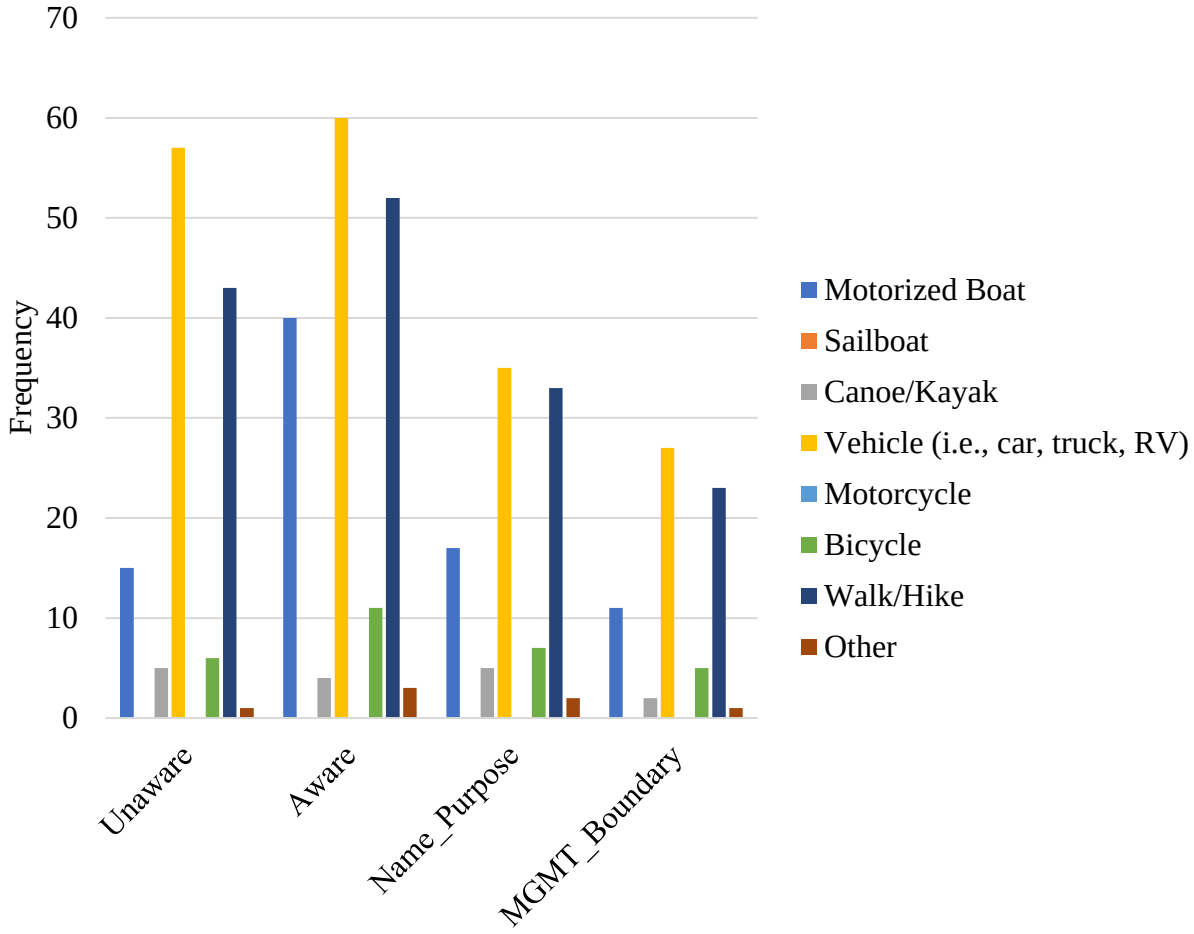


Figure 4. 7: Primary activity type by VAI Group

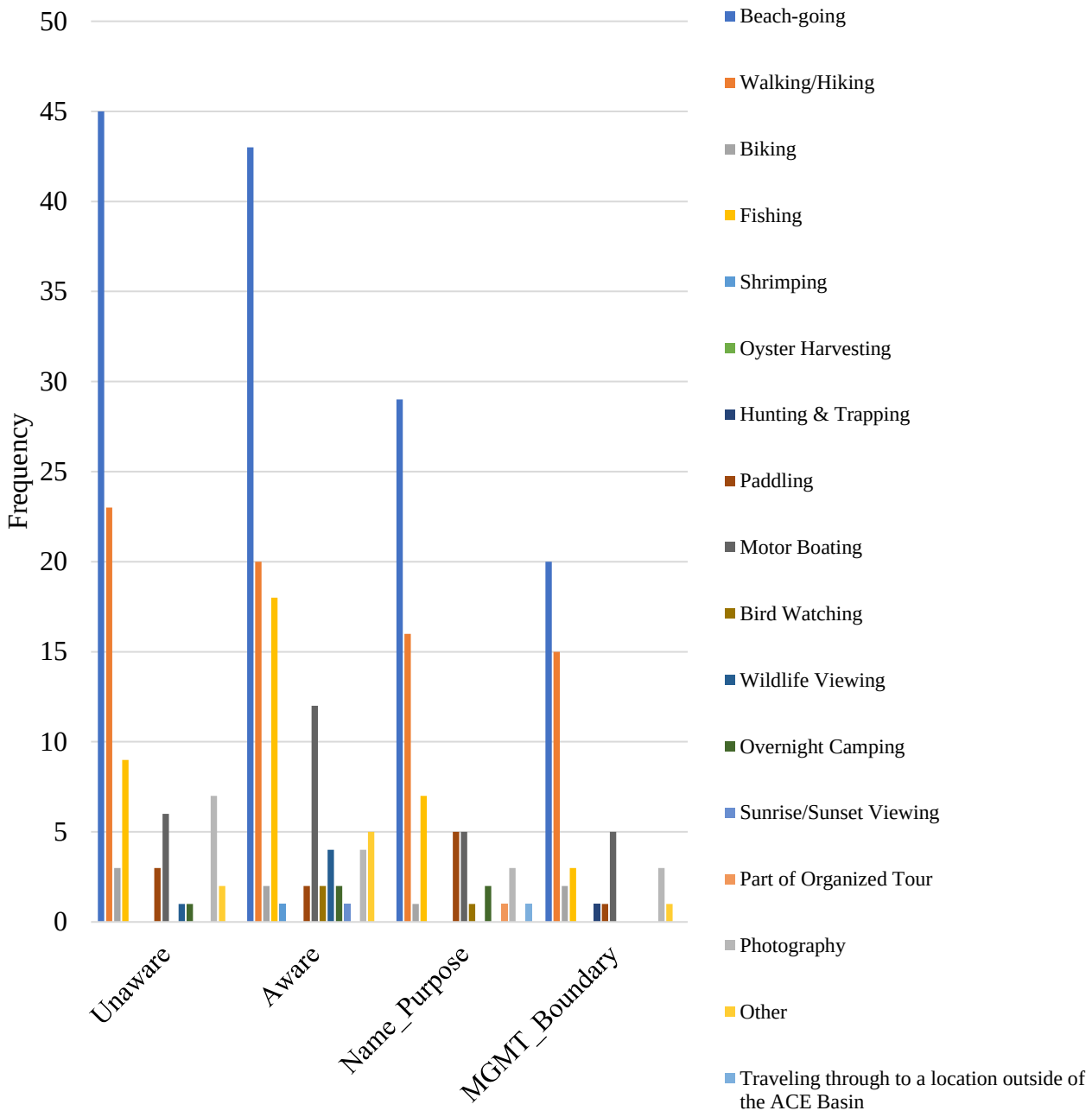


Figure 4. 8: Level of crowding experienced at Botany Bay WMAHP by mean VAI group (% of sample in bubble)

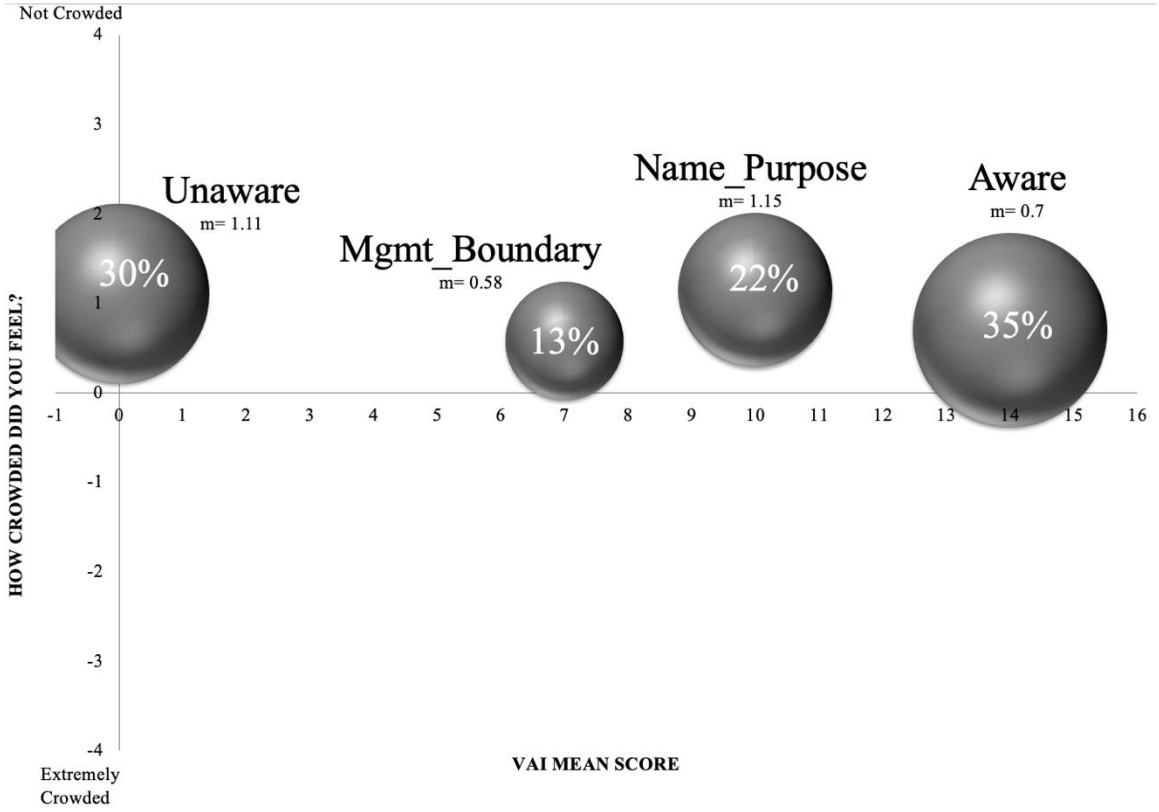


Figure 4. 9: Influence on quality of experience when encountering too many people at Botany Bay WMAHP by VAI group (% of sample in bubble)

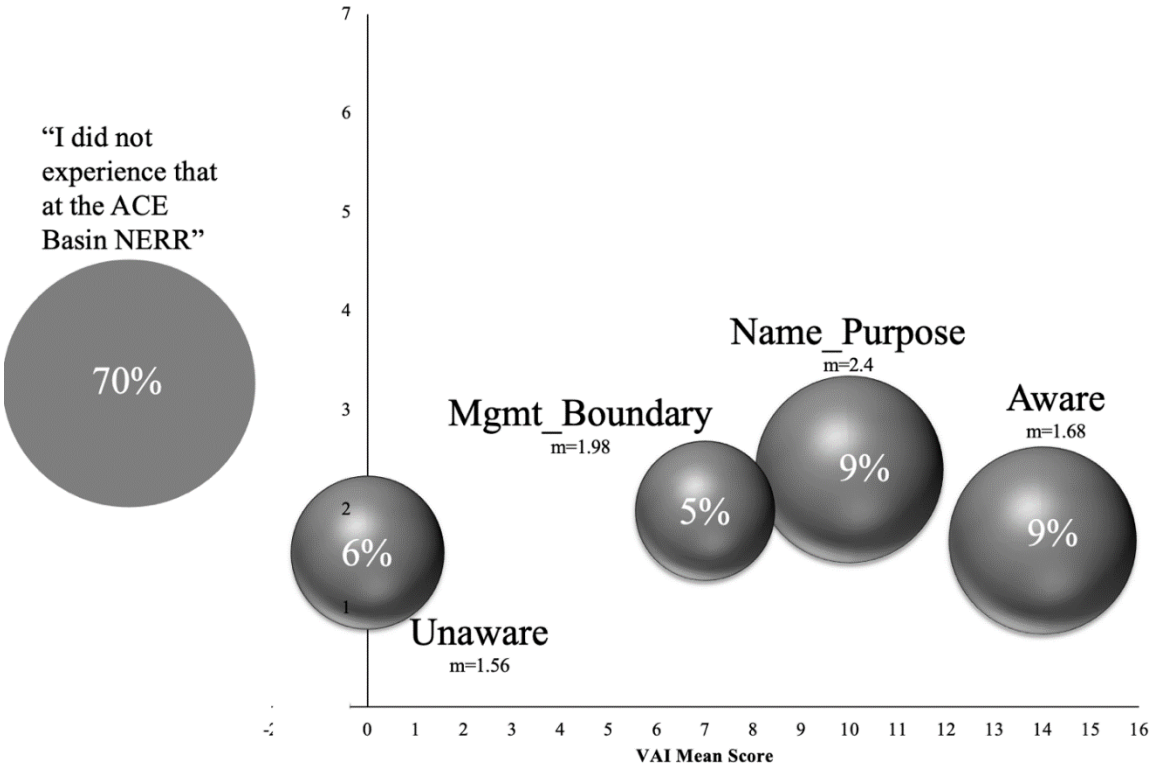
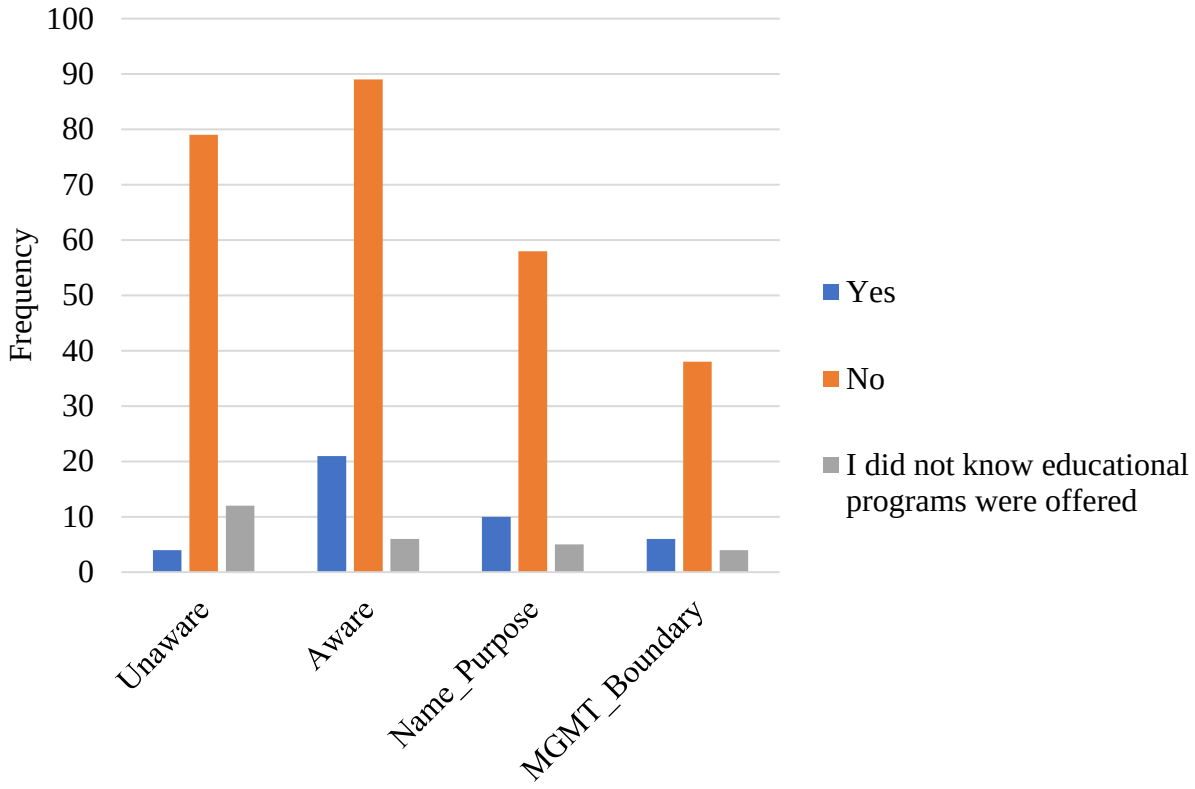


Figure 4. 10: Participation in educational programing by VAI group



CHAPTER 5

SUMMARY AND SYNTHESIS

The final chapter of this dissertation focuses on a brief review of each of the three main chapters, including significant findings, implications, and limitations that occurred during the data collection. This chapter also focuses on the significance and challenges coastal protected areas (CPAs) face and why these areas were the focus of the dissertation. Finally, a brief section is included on the importance of the work that was done throughout this dissertation and the need to continue to explore new data collection techniques and concepts throughout the field of park and protected area (PPA) management.

This dissertation aimed to explore and advance the science of visitor use management (VUM) and natural resource management, particularly in CPAs. The array of theories, tools, and techniques used throughout the three chapters push the boundaries and built off of what is traditionally used in our field of research. The overall results from this dissertation reveal the multitude of complexities even when asking seemingly simple questions. When you distill the major questions this dissertation asks, you end up with Chapter 2 asking "How many visitors are using this area?" and "When are they going there?", Chapter 3 asking "Does the public care about oyster farming?" and "Can we use virtual reality (VR) to measure that?", and finally in Chapter 4 "What is awareness?" and "Does awareness matter?". Although these questions were asked primarily within CPAs, these questions could apply to any PPA given minimal contextual changes. The tools and techniques utilized throughout this dissertation aimed to test the efficacy of their utilization within recreation research. These technologies may be

commonplace in other fields of research but have been slow to make their way into VUM research.

Comparisons of Chapters

Chapter 2 of this dissertation highlights the utilization of location-based services (LBS) data to determine visitor use patterns, compares this to traditional field camera data collection, and tests whether LBS can be used to answer specific management outcomes. The results showed that LBS data can be a reliable tool for visitor estimation in high use areas, but its reliability and utility seem to decrease in low use settings. Due to these limitations, LBS data may not be able to completely evaluate management decisions but could provide indicators of specific management outcomes. Even during the timeframe of this study, the algorithm and data sources that are involved with LBS data went through significant changes. This shows that the technology is continually changing but the effects these changes have on its utility for recreation research should be continually explored. If I were to conduct the same or similar study over again, I believe it would have been beneficial to monitor the field cameras more regularly. As highlighted in Chapter 2, coastal areas present a host of field equipment management challenges that I was not accustomed to. As a result, the field cameras were pushed to their 'weatherproof' capabilities and in some instances did not collect the full set of desired data. Although this extra set of data may have not been essential to calibrating or validating the LBS data, it would have been nice to have a uniform timeframe for all field cameras.

Chapter 3 applies the theories and techniques that are traditionally used to measure the acceptability of crowding but puts it in the context of measuring the public's

acceptability of oyster mariculture production. It was found that although information about oyster mariculture is lacking among stakeholders, the introduction of relatively limited scientific and objective information through the participation of our survey was enough to influence their opinions. These findings could have far-reaching implications for managers of the intercoastal waterways where oyster mariculture is possible and could also be applied to other management objectives for these areas. This chapter also explores the utilization of virtual reality (VR) technologies as a tool of survey research in a field setting and to measure the acceptability of differing sizes and arrangements of an oyster farm. The results of this study reveal complexities of utilizing VR technology but opens the door for more comprehensive research into the efficacy of VR in field-based research. Reflecting on the data collection process, I believe one limitation to this study was the development of the VR imagery utilized in the survey. Although it was representative of what conditions could look like with varying oyster mariculture arrangements, I believe it could have been executed better. This was my first time developing simulated images and videos for the purposes of VR display. There were a number of hurdles encountered during the development of the images, which with more practice, could result in more realistic immersive virtual reality (IVR) for participants to experience. One of the major hurdles that I wish could have been resolved was the rendering speed of the IVR video experience. The 360° camera used produced a partially pixilated video of the oyster farm. It is my opinion that this was due to the speed of the boat as we were filming these scenes. The shutter speed and rendering power of the camera may not have been appropriate for the type of filming necessary. Although these

limitations may not have had dramatic effects on the results of this study, clearer, more thoroughly produced images would be warranted for further research.

With that further research, I believe it would be interesting to use VR technologies to recreate “at one time” (AOT) threshold studies that only utilized 8”x10” photographs to simulate conditions. Like I had mention in Chapter 3, I believe that the sensation of crowding and the acceptance of visitors is very much based on perspective. Displaying photographs of a crowd and asking how acceptable that condition would be is vastly different than immersing an individual within a crowd of that same size and asking the same question. It is my belief that visitation thresholds would dramatically decrease in comparative VR studies which could provide for a host of research opportunities and management implications.

Chapter 4 took the experiences of the authors and created a Visitor Awareness Index (VAI) that could measure how aware visitors were about the park or protected area (PPA) they were visiting, the relationship between awareness and visitor characteristics, and what benefits might this awareness have for managers. The outcomes of this chapter suggest that awareness level is not necessarily reflected in the types of visitors, or the types of recreation visitors participate in. Awareness level also did not influence specific place-based perceptions but could, however, be influenced by the actions of management. One aspect that this research did not account for and that could have been improved upon is really investigating why awareness is so important to PPA managers. Although the results of this research found that there were relatively few tangible management actions that can be taken away from this iteration of awareness research, Dr. Hallo and I still think that there is an inherent importance to measuring awareness of visitors. The fact

that managers put an emphasis on wanting to know visitors' awareness could be the reason *why* awareness matters. Future research may want to turn the focus away from visitors and conduct research on PPA managers from a number of different agencies, environments, and locations to see why they believe visitor awareness matters and how they believe it can be incorporated into their management decisions.

Management Implications

There are many reasons why I wanted to focus my research within coastal protected areas (CPAs). First off, who wouldn't want their work to be on the beach? As someone who grew up in the cold of Buffalo, NY, the beaches of the Southeast have always been a draw for me. It was during my undergraduate years at Eckerd College, however, that I began to truly see the challenges coastal areas face. Many of the environmental and biology classes always had a coastal context which drove my passion for these areas even further. As stated in the introduction of this dissertation, CPAs are socially, environmentally, and economically significant, and I believe my research touches upon each of these dimensions.

Coastal areas within the continental U.S. are home to nearly 40% of the nation's population while only containing 10% of its landmass. Compounded by the nearly 200 million visitors these areas receive each year, the coast is clearly an immensely important region to the public. Coastal areas also provide for innumerable recreation opportunities that cannot be found anywhere else. By finding better ways for monitoring this visitation, like in Chapter 2, we can better understand the use dynamics, minimizing the environmental effects we have on these areas.

CPAs in particular provide areas that are increasingly scarce. These protected oases among the overdeveloped coast are places of immense environmental importance. Countless numbers of fauna and flora are endemic to these regions along with being vitally important habitats that provide critical breeding and nursery grounds for species. Awareness of this importance is critical if managers are to get visitors on board with helping protect these areas. The concepts and measurements for this awareness were explored in Chapter 4 with the goal of finding better ways of understanding awareness' influence on how visitors use CPAs.

The economics of coastal areas, and CPAs in particular, are where their social and environmental importance collide. Not only do these areas generate monetary values through tourism dollars and consumptive products, but they also provide for ecosystem services (e.g., water filtration, carbon storage, storm surge protection) that are much tougher to monetize. Chapter 3 took a look at the public's acceptance of furthering the economic output of coastal areas. Oyster mariculture is a unique practice that can inevitably provide both consumptive products to generate profits along with ecological service improvements, while protecting coastal cultures and ways of life.

Final Thoughts

The three chapters that are contained within this dissertation cover a spectrum of questions, methods, and technologies exemplifying the range and complexities that is VUM research. A general principal of science is that we aim for generalizability and repeatability of our work, but this can be quite difficult in PPA research. Visitor use is dynamic and ever changing. The true nature of our work only captures a snapshot in time highlighting the attitudes, perceptions, and behaviors of those visitors who participate in

our studies. This is why for this dissertation, I chose to not only focus on specific management questions of the CPAs I was conducting research for, but to explore better methods to collect that data. The methods within VUM research are what can be replicated and used throughout our field. I believe it is important that we examine and reexamine how data is collected and explore the technologies from other fields of research and apply them to our own. As visitation evolves, so should our research. Equipped with new technologies and new conceptualizations of existing ideas, researchers and managers alike will be able to keep up with and better understand the attitudes, perceptions, and behaviors of current stakeholders within PPAs. It is my hope that the research contained within this dissertation may contribute to the ever-growing effort to balancing visitor use and natural resource management.

APPENDIX A

Survey of Public Perceptions of Oyster Farming in South Carolina

1. Why are you in Charleston or Beaufort County, SC today?

- ❑ I live here → I own land in view of a coastal waterway? ❑ Yes ❑ No
- ❑ I'm working here but don't live in these counties
- ❑ I'm a tourist or visitor who lives outside of these counties
- ❑ Other (please specify): _____

2. What is your home zip code? _____

3. How do you use the tidal creeks and rivers in Charleston or Beaufort Counties, and how often? (check <u>all</u> that apply)

- ❑ For recreational boating ⟶ How many times in the last year? _____
- ❑ For fishing or shrimping ⟶ How many times in the last year? _____
- ❑ Oyster harvesting ⟶ How many times in the last year? _____
- ❑ For scenic viewing from land ⟶ How many times in the last year? _____
- ❑ For work purposes ⟶ How many times in the last year? _____
- ❑ Other (please specify): _____
- ❑ I don't use or view tidal creeks and rivers in these counties

4. Do you eat oysters, and if so, how often in the last year? (check <u>all</u> that apply)

- ❑ Yes, raw oysters ⟶ How many times in the last year? _____
- ❑ Yes, cooked oysters ⟶ How many times in the last year? _____
- ❑ No

5. Where did the oysters you ate in the last year grow? (check <u>all</u> that apply)

- ❑ In South Carolina
- ❑ In other areas of the Atlantic Coast
- ❑ Pacific Coast
- ❑ Don't know/Not sure
- ❑ Other (please specify): _____

6. Were the oysters you ate in the last year wild or farm raised? (check <u>all</u> that apply)

- ❑ Wild, from naturally occurring oyster beds in tidal creeks and rivers
- ❑ Raised in oyster farms, which are in tidal creeks and rivers
- ❑ Don't know/Not sure

7. Please list the top three words or short phrases that you'd use to describe your feelings toward <u>oysters raised in farms (i.e., mariculture)</u>, which are located in tidal creeks and rivers.

*1.*_____ *2.*_____
*3.*_____

8. How much do you support or oppose farming of oysters? (check <u>one</u> box)

Strongly Oppose			**Neutral**			**Strongly Support**	**Don't Know**
❑	❑	❑	❑	❑	❑	❑	❑

9. Please explain the reasons for your support or opposition.

_____
_____
_____

10. How much do you know about oyster farms and farmed oysters?

- ❑ Nothing
- ❑ A little
- ❑ A good bit
- ❑ A lot

11. Please look at the pictures for Question 11 in the binder you were given of the floating cages in a South Carolina oyster farm, from up close and far away. Farmed oysters are grown in cages in public tidal creeks and rivers. Oyster farms are specifically permitted and overseen by state and federal agencies, according to specific guidelines. Some cages sit on the bottom, but newer cages float on the top of the water. Cages are often checked on or serviced daily for a few hours by the oyster farmer from a typical motorboat. The public still has legal access to and can use the waters in and around these oyster farms. A farm's location is placed to ensure that no more than one-third of any navigable channel is used and that the farm is offset from the shoreline and major navigational routes. What concerns, if any, do you have about oyster farms or eating oysters from these farms?

_____
_____
_____

12. Do you think oyster farming fits into the local culture of this area?

- ❑ Yes
- ❑ No
- ❑ Don't know/Not sure

13. Please indicate the extent that the following are concerns for you when considering your support or opposition to oyster farms. This list of concerns is based on potential perceptions, individual opinions, or your experiences, not necessarily on scientific or objective information. (*Check one box for each issue or indicate that you don't know*.)

	Big Concern ⟷				**Not a Concern**	**Don't Know**
Adequate permitting and oversight of oyster farms by governmental agencies	-2	-1	0	+1	+2	❑
Good management and operation of oyster farms by their owners	-2	-1	0	+1	+2	❑
Oyster farms being too big	-2	-1	0	+1	+2	❑
Oyster farms being unsightly, ugly, or ruining a scenic view	-2	-1	0	+1	+2	❑
Negative impacts of oyster farms on the environment	-2	-1	0	+1	+2	❑
Oyster farms being too near things like bridges or cities	-2	-1	0	+1	+2	❑
Negative impacts of oyster farms on wild oysters	-2	-1	0	+1	+2	❑
Navigating a boat safely around oyster farms	-2	-1	0	+1	+2	❑
Using public waterways for commercial purposes	-2	-1	0	+1	+2	❑
Loss of access to or use of public waterways	-2	-1	0	+1	+2	❑
Lack of on-site signage or marking of oyster farms	-2	-1	0	+1	+2	❑
Oyster cages breaking loose and becoming litter	-2	-1	0	+1	+2	❑
Oyster farms owned by those outside of South Carolina	-2	-1	0	+1	+2	❑
Other (*please specify*): _____	-2	-1	0	+1	+2	❑

14. Based on scientific or objective information, oyster farms are thought to be beneficial in the ways listed below. How important are these in helping you to decide your support or opposition to oyster farms? (*Check one box for each issue or indicate that you don't know*.)

	Not Important ⟷				**Very Important**	**Don't Know**
Oyster farms help filter excess nutrients from the water	-2	-1	0	+1	+2	❑
Oyster farms help reduce harvest pressure on wild oysters	-2	-1	0	+1	+2	❑
Oyster farms help provide a more reliable source for consumption	-2	-1	0	+1	+2	❑
Oyster farms help provide economic benefits and local jobs	-2	-1	0	+1	+2	❑
Oyster farms help provide a local food for restaurants and people	-2	-1	0	+1	+2	❑
Farmed oysters are somewhat more sustainable and ocean-friendly than wild oysters	-2	-1	0	+1	+2	❑
Oyster farms <u>may</u> produce oysters that are safer to eat	-2	-1	0	+1	+2	❑
Oyster farms <u>may</u> provide habitat for other marine life	-2	-1	0	+1	+2	❑
Very few oyster farms currently exist in South Carolina, but substantial potential and demand exists for their growth. The same equipment and techniques used frequently and for decades in other states could help increase the amount of oyster farming in the state and the benefits described above.	-2	-1	0	+1	+2	❑

15. Considering the information in this survey, how much do you support or oppose farming of oysters?

Strongly Oppose			**Neutral**			**Strongly Support**	**Don't Know**
❑	❑	❑	❑	❑	❑	❑	❑

16. We would like to know how the size and proximity of an oyster farm in the tidal creeks and rivers that you use affect how acceptable you think they are. Oyster farms may be located along waterways in long but narrow configurations, while others may be more concentrated in an area. We have portrayed this visually or by describing it.

Please note that these visuals are of locations with an oyster farm present. Your experience using or viewing tidal creeks and rivers would likely include long portions of the waterway where oyster farms are not view.

16.1a. Please rate each photo in Panel A by indicating how acceptable or unacceptable you think it is. A rating of -4 means it is "very unacceptable", and a rating of +4 means it is "very acceptable". (*Circle one number for each row*.)

		Very Unacceptable				**Neutral**				**Very Acceptable**
Panel A	Distance Photo 1	-4	-3	-2	-1	0	+1	+2	+3	+4
	Distance Photo 2	-4	-3	-2	-1	0	+1	+2	+3	+4
	Distance Photo 3	-4	-3	-2	-1	0	+1	+2	+3	+4
	Distance Photo 4	-4	-3	-2	-1	0	+1	+2	+3	+4
	Distance Photo 5	-4	-3	-2	-1	0	+1	+2	+3	+4
	Distance Photo 6	-4	-3	-2	-1	0	+1	+2	+3	+4
	Distance Photo 7	-4	-3	-2	-1	0	+1	+2	+3	+4
	Distance Photo 8	-4	-3	-2	-1	0	+1	+2	+3	+4

16.1b. Which distance photo from Panel A shows the closest to you that oyster farm should be permitted to occur by agencies?

Photo number: _____ **OR** ❑ Oyster farms should not be allowed **OR** ❑ Oyster farm sizes should not be restricted

At this point, you will need assistance to proceed with the virtual reality portion of the survey. Please notify the person that gave you the survey that you are ready for the VR headset and they will provide further instructions.

Thank you for completing this survey! Please return it to the person who gave it to you.

Responses to this request are voluntary and anonymous. Direct comments regarding this survey or other aspect of this data collection to: Dr. Jeffrey C. Hallo, Professor, Clemson University, jhallo@clemson.edu

16.2a. Please rate each photo in Panel B by indicating how acceptable or unacceptable you think it is. A rating of -4 means it is "very unacceptable", and a rating of +4 means it is "very acceptable". (*Circle one number for each row*.)

		Very Unacceptable				**Neutral**				**Very Acceptable**
Panel B	Size Photo 1	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Photo 2	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Photo 3	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Photo 4	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Photo 5	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Photo 6	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Photo 7	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Photo 8	-4	-3	-2	-1	0	+1	+2	+3	+4

16.2b. Which photo from Panel B shows the largest oyster farm that should be permitted along a waterway by agencies?

Photo number: _____ **OR** ❑ Oyster farms should not be allowed **OR** ❑ Oyster farm sizes should not be restricted

16.3a. Please rate each videos or descriptions in Panel C by indicating how acceptable or unacceptable you think it is. A rating of -4 means it is "very unacceptable", and a rating of +4 means it is "very acceptable". (*Circle one number for each row*.)

Narration: Imagine yourself traveling full speed on a motorboat down an intercoastal waterway. On your right side is an oyster farm of [300, 900, 1500, 1800 cages] that goes the length of the waterway for about [40 seconds, 2min, 3:30min, 4min]. How acceptable or unacceptable would this experience be for you?

		Very Unacceptable				Neutral				Very Acceptable
Panel C	A farm with 300 cages	-4	-3	-2	-1	0	+1	+2	+3	+4
	A farm with 900 cages	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Video 1 (300 cages)	-4	-3	-2	-1	0	+1	+2	+3	+4
	Size Video 2 (900 cages)	-4	-3	-2	-1	0	+1	+2	+3	+4
	A farm with 1,500 cages	-4	-3	-2	-1	0	+1	+2	+3	+4
	A farm with 1,800 cages	-4	-3	-2	-1	0	+1	+2	+3	+4

16.3b. Which size video or description from Panel C shows the largest size oyster farm that should be permitted in one place by agencies?

Video or size number: _____ **OR** ❑ Oyster farms should not be allowed **OR** ❑ Oyster farm distance should not be restricted

Thank you for completing this survey! Please return it to the person who gave it to you.

Responses to this request are voluntary and anonymous. Direct comments regarding this survey or other aspect of this data collection to: Dr. Jeffrey C. Hallo, Professor, Clemson University, jhallo@clemson.edu

APPENDIX B

NPS Pool of Known Questions that Address Awareness

National Park Service (2019)

ITIN21

Which area managed by each of the federal land management agencies below do you plan to use your pass during this trip?

≤		**National Park Service NPS Sites [list specific NPS SITES]**
≤		**Bureau of Land Management NPS Sites [list specific NPS SITES]**
≤		**U.S. Fish and Wildlife Service NPS Sites [list specific NPS SITES]**
≤		**U.S. Forest Service NPS Sites [list specific NPS SITES]**
≤		**Bureau of Reclamation NPS Sites [list specific NPS SITES]**

ITIN22

When planning your trip were you aware of the agencies managing [NPS SITES] where you use your Annual Pass the most? Which of the following statements best describes your knowledge of the managing agency? (Please select one response)

- I was very aware which agency managed [NPS SITES] when I planned my visit
- I was somewhat aware of which agency managed [NPS SITES] when I planned my visit
- I was not at all aware of which agency managed [NPS SITES] when I planned my visit

TRAFFIC12

Were you aware that you were driving through [NPS SITE], which is part of the U.S. National Park System?

≤ NO

≤ YES

a. How did you first become aware that you were driving through [NPS SITE]?

_____

b. Why did you choose to drive through [NPS SITE] today?

_____

KNOW1

Prior to this visit, were you aware that [NPS SITE] is managed by the National Park Service (NPS)?

- YES
- NO
- Not sure

KNOW2

Are you aware that [NPS SITE] is an area managed by the National Park Service?

- YES
- NO
- Not sure

KNOW3

Prior to this visit to [NPS SITE], were you aware of the difference between a national park area and a national forest?

- YES
- NO
- Not sure

KNOW4

Prior to this visit, did you know anything about the history of this site?

- YES
- NO
- Not sure

KNOW5

Prior to this visit, were you [and your personal group] familiar with [NPS SITE] rules and regulations?

- YES
- NO
- Not sure

KNOW6

How familiar are you with the federal designation of [NPS SITE]?

- Very familiar
- Moderately familiar
- Slightly familiar
- Not at all familiar

KNOW7

Who do you think manages this area?

- Bureau of Land Management
- Department of Fish and Game
- Parks and Recreation
- National Park Service
- U.S. Forest Service
- More than one
- Don't know

KNOW15

The following list will help us understand how familiar people are with wilderness [NPS RULES/REGULATIONS]. Please indicate if you think each of the following statements is TRUE or FALSE, or if you don't know.

	True	False	Don't know
Wilderness areas are established by Congress	1	2	DK
Motor vehicles are allowed in wilderness areas	1	2	DK
Wilderness areas are managed by the Bureau of Land Management, the Fish and Wildlife Service, the Forest Service and the National Park Service	1	2	DK
Hunting is not allowed in wilderness areas	1	2	DK
Designated wilderness areas exist in almost every state in the country	1	2	DK
Wilderness areas are managed primarily to protect natural conditions, but also may be used for growing timber	1	2	DK
All National Park lands are part of the United States wilderness system	1	2	DK
Fishing is allowed in wilderness areas	1	2	DK
Wilderness areas were established to help handle the growing need for recreation areas.	1	2	DK
Bicycles are not allowed in wilderness areas	1	2	DK
Roads are developed in wilderness for fire protection and recreational access	1	2	DK
Small cabins are allowed in wilderness for overnight visitors.	1	2	DK

HDW16

Prior to your visit, were you aware of food storage regulations to protect wildlife at [NPS SITE]?

- YES
- NO → Go to part (d) of this question

b) Prior to your visit, were you aware that food storage regulations apply to all forms of wildlife at [NPS SITE]? Please select **one** response**.**

- YES
- NO

c) Prior to your visit, were you aware that food storage regulations apply to any item with a scent, regardless of packaging (including toiletries, canned goods, trash)? Please select ☒ **one.**

- YES
- NO

d) During your visit, where did you learn about food storage regulations? Please select ☒ **all that apply.**

- Personal contact with a ranger
- Brochures, exhibits, or other means

OR

- I didn't receive any information about food storage during my visit

PART2

[NAME OF PARTNER/FRIENDS GROUP] is a friends group that supports [NPS SITE] through educational programs, awareness, and funding. Prior to this visit, were you aware of the [NAME OF PARTNER/FRIENDS GROUP]?

- YES
- NO

TRAFFIC12

Were you aware that you were driving through [NPS SITE], which is part of the U.S. National Park System?

≤ NO

≤ YES

a. How did you first become aware that you were driving through [NPS SITE]?

_____

b. Why did you choose to drive through [NPS SITE] today?

_____

APPENDIX C

Visitor Survey Distributed at ACE Basin NERR

Visitor Survey

1. We would like to know how aware you are of the place you are visiting today. Many people are not aware of this, so it is OK if you are not. Please just answer as correctly as possible.

How aware are you that:

…You are visiting a location within the ACE BASIN National Estuarine Research Reserve?

Not at all aware				Completely aware
1	2	3	4	5
○	○	○	○	○

…The purpose of the ACE Basin NERR is to "*Sustain the ecological health of the ACE Basin's estuaries and provide natural areas for research, education, stewardship, and compatible human uses*"?

Not at all aware				Completely aware
1	2	3	4	5
○	○	○	○	○

…The ACE Basin NERR is managed jointly by the South Carolina Department of Natural Resources (SCDNR) and the National Oceanic and Atmospheric Association (NOAA)?

Not at all aware				Completely aware
1	2	3	4	5
○	○	○	○	○

…That the boundary of the ACE Basin NERR is what is shown on the map provided?

Not at all aware				Completely aware
1	2	3	4	5
○	○	○	○	○

ACE Basin National Estuarine Research Reserve (NERR)
Visitor Survey

The ACE Basin encompasses approximately 100,000 acres of diverse habitat in Beaufort, Colleton, and Charleston Counties in southeastern South Carolina (See map provided). For the purposes of this study, please focus your answers to the area on the map that is **within** the "NERR Boundary".

2. Is this your first time at the ACE Basin NERR? Yes ◯ No ◯
   (If 'Yes', Skip to Question 6)

3. Including today, how many **days in the last month** (30 days) have you visited within the ACE Basin NERR boundary? _____

4. Including today, how many **days in the last year** (12 months) have you visited within the ACE Basin NERR boundary? _____

5. How long is your **average stay** within the ACE Basin NERR boundary?

   - ○ Less than 1 hour
   - ○ 1-4 hours
   - ○ 5-9 hours
   - ○ 10-14 hours
   - ○ 1-2 days
   - ○ 3 or more days

6. During **this trip**, how long do you plan to stay within the ACE Basin NERR boundary?

   - ○ Less than 1 hour
   - ○ 1-4 hours
   - ○ 5-9 hours
   - ○ 10-14 hours
   - ○ 1-2 days
   - ○ 3 or more days

7. What did you like **most** about your trip within the ACE Basin NERR boundary?

   _____

   _____

8. What did you like **least** about your trip within the ACE Basin NERR boundary?

   _____

   _____

9. What would you ask managers to **change** within the ACE Basin NERR boundary?

_____

_____

10. Using the scale below, please rate the level of crowding you experienced within the ACE Basin NERR boundary today. Please select the number that best matches your response:

Extremely Crowded				Moderately Crowded				Not Crowded
(-4)	(-3)	(-2)	(-1)	(0)	(+1)	(+2)	(+3)	(+4)
○	○	○	○	○	○	○	○	○

11. Please indicate if you have experienced any of the following during this visit or a previous visit within the ACE Basin NERR boundary.
a. Please check **all that apply**.

	Experienced during your **current** visit to the reserve	Experienced during a **previous** visit to the reserve
Chose to **not visit** ACE Basin NERR because there were too many visitors	○	○
Chose **to not visit your desired places** in the reserve because there were too many visitors	○	○
Chose **to not engage in your desired activities** because there were too many visitors	○	○
Changed the time or days that you visited because there were too many visitors	○	○

b. Please specify which areas within the ACE Basin NERR you have experienced overcrowding.

_____

_____

12. Please indicate which of the following locations you visited within the ACE Basin NERR boundary during your **current visit**.

a. Please check **all that apply**.

- ○ Botany Bay Wildlife Management Area
- ○ Hunting Island State Park
- ○ Edisto Island State Park
- ○ Bear Island Wildlife Management Area
- ○ Donnelley Wildlife Management Area
- ○ St. Helena Sound Wildlife Management Area
- ○ South Fenwick Island
- ○ Otter Island
- ○ Pine Island
- ○ Edisto Environmental Learning Center
- ○ Ernest F. Hollings National Wildlife Refuge
- ○ Grove Plantation
- ○ Other _____
- ○ I did not visit any of these areas
- ○ I do not know the names of the places I visited

b. Using the list above, what was the **main area** within the ACE Basin NERR boundary that you visited during your **current visit**?

_____

c. Using the list above, what areas within the ACE Basin NERR boundary did you visit during your **previous visits**? (List all that apply)

_____

_____

13. What was your primary mode of travel while recreating within the ACE Basin NERR boundary?

- ○ Motorized Boat
- ○ Vehicle (i.e., car, truck, RV)
- ○ Bicycle
- ○ Sailboat
- ○ Walk/Hike
- ○ Canoe/ Kayak
- ○ Motorcycle
- ○ Other_____

14. **a.** Which boat launch did you use during your **current** visit?
(If you did not use a boat launch, please skip to Question 15)

_____

b. On average, how long did you have to wait at the boat launch **on this visit**?

- ○ 0 minutes
- ○ 5 minutes
- ○ 10 minutes
- ○ 20 minutes
- ○ 30 minutes
- ○ 45 minutes
- ○ 1 hour or more
- ○ I did not use a boat launch on this trip

15. What activities do you participate in while recreating in ACE Basin NERR boundary?
a. Select all that apply

- ○ Beach-going
- ○ Walking/Hiking
- ○ Biking
- ○ Fishing
- ○ Shrimping
- ○ Oyster Harvesting
- ○ Hunting & Trapping
- ○ Paddling
- ○ Motor boating
- ○ Bird Watching
- ○ Wildlife Viewing
- ○ Overnight Camping
- ○ Sunrise/Sunset Viewing
- ○ Educational Program
- ○ Part of Organized Tour
- ○ Photography
- ○ Other _____
- ○ Traveling through to a location outside the ACE Basin NERR

b. Using the list above, what was your **primary** activity while within the ACE Basin NERR boundary?

_____

16. Have you ever participated in an educational program while at ACE Basin NERR?

Yes → Please provide the name of the program and the location of the program	No	I did not know educational programs were offered
○ _____	○	○

17. The following are conditions or experiences that might influence the quality of a visitor's experience at the ACE Basin NERR.

a. Please select one answer for each item below to indicate how much that experience influenced the quality of your visit.

	I did not experience this at the ACE Basin NERR	**Did not at all** influence the quality of my experience (1)	(2)	(3)	(4)	(5)	(6)	**Extremely influenced** the quality of my experience (7)
Boats speeding in a "No Wake Zone"	○	○	○	○	○	○	○	○
Too many boats encountered while on the water during a day	○	○	○	○	○	○	○	○
Too many boats at one time in a specific location	○	○	○	○	○	○	○	○
Too many dogs on a beach	○	○	○	○	○	○	○	○
Visitors negatively impacting wildlife and natural resources	○	○	○	○	○	○	○	○
Visitors behaving badly or interfering with you experience	○	○	○	○	○	○	○	○
Visitor breaking rules	○	○	○	○	○	○	○	○
Long waits at boat launches	○	○	○	○	○	○	○	○
Too many people on a beach at one time	○	○	○	○	○	○	○	○
Amount of litter seen	○	○	○	○	○	○	○	○

17 (continued). The following are conditions or experiences that might influence the quality of a visitor's experience at the ACE Basin NERR.

a. Please select one answer for each item below to indicate how much that experience influenced the quality of your visit.

	I did not experience this at the ACE Basin NERR	**Did not at all** influence the quality of my experience (1)	(2)	(3)	(4)	(5)	(6)	**Extremely influenced** the quality of my experience (7)
Too many people encountered per visit at Botany Bay WMA	○	○	○	○	○	○	○	○
Too many people encountered per visit at Otter Island	○	○	○	○	○	○	○	○
Too many people encountered per visit at Pine Island	○	○	○	○	○	○	○	○
Adequate parking at high-use attraction sites (e.g., boat launches, Botany Bay WMA, Edisto State Beach)	○	○	○	○	○	○	○	○
Adequate bathroom and drinking water facilities at high-use attraction site (e.g., boat launches, Botany Bay WMA, Edisto State Beach)	○	○	○	○	○	○	○	○
Too little wildlife seen	○	○	○	○	○	○	○	○
Adequate and helpful staff	○	○	○	○	○	○	○	○
Adequate and interesting educational programs	○	○	○	○	○	○	○	○

b. Using the same list from the previous question, please write the factor that **most influenced** the quality of your **current** visit.

_____

18. We would like to know how many **people, on average, is acceptable to encounter on the beach at Botany Bay WMA during an hour visit**. Please skip this question if you have not been to the beach at Botany Bay WMA.

a. Please rate each number of encounters on the beach per hour.

	Very Unacceptable	**Unacceptable**	**Moderately Unacceptable**	**Slightly Unacceptable**	**Neither Acceptable or Unacceptable**	**Slightly Acceptable**	**Moderately Acceptable**	**Acceptable**	**Very Acceptable**
0 people encountered on the beach in a 1-hour visit	-4	-3	-2	-1	0	+1	+2	+3	+4
10 people encountered on the beach in a 1-hour visit	-4	-3	-2	-1	0	+1	+2	+3	+4
20 people encountered on the beach in a 1-hour visit	-4	-3	-2	-1	0	+1	+2	+3	+4
40 people encountered on the beach in a 1-hour visit	-4	-3	-2	-1	0	+1	+2	+3	+4
80 people encountered on the beach in a 1-hour visit	-4	-3	-2	-1	0	+1	+2	+3	+4
160 people encountered on the beach in a 1-hour visit	-4	-3	-2	-1	0	+1	+2	+3	+4

b. How many people did you **encounter on the beach at Botany Bay WMA per hour** on your **most recent** visit?

Number of people encountered on the beach per hour: _____ **OR** ○ I don't know or cannot estimate the number of people that I encountered **OR** ○ I did not go to Botany Bay WMA

19. How many people did you **encounter on the beach on Otter Island per hour** on your **most recent** visit?

Number of people encountered on the beach per hour: _____ **OR** ○ I don't know or cannot estimate the number of people that I encountered **OR** ○ I did not go to Otter Island

20. How many people did you **encounter on the beach on Pine Island per hour** on your **most recent** visit?

Number of people encountered on the beach per hour: _____ **OR** ○ I don't know or cannot estimate the number of people that I encountered **OR** ○ I did not go to Pine Island

21. What is your ZIP code? _____

22. What **year** were you born? _____

23. What is your ○ Male ○ Female ○ Other gender?

24. What is the highest level of school you have completed or the highest degree you have received?

○ Less than high school degree
○ High school graduate (high school diploma or equivalent including GED)
○ Some college but no degree
○ Associate degree in college (2-year)
○ Bachelor's degree in college (4-year)
○ Master's degree
○ Doctoral degree
○ Professional degree (JD, MD)
○ Do not wish to answer

25. Which race do you consider yourself to be? (Select all that apply)

○ White
○ Black or African American
○ Hispanic or Latino/Latina
○ American Indian or Alaska Native
○ Asian
○ Native Hawaiian or Pacific Islander
○ Other _____

26. Which category best describes your total household income in 2021 before taxes?

○ Less than $24,999
○ $25,000 to $34,999
○ $35,000 to $49,999
○ $50,000 to $74,999
○ $75,000 to $99,999
○ $100,000 to $149,999
○ $150,000 to $199,999
○ $200,000 or more
○ Do not wish to answer