Let's talk about seagrasses! A front-end evaluation to improve messaging strategies for seagrass conservation in Indian River Lagoon visitor centers

by

Amy Durham Shea

A PROJECT

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Natural Resources in Natural Resources

Presented March 22, 2023
Commencement June 2023

ABSTRACT OF THE PROJECT OF

Amy Durham Shea for the degree of Master of Natural Resources presented on March 22, 2023
Title: Let's talk about seagrasses! A front-end evaluation to improve messaging strategies for seagrass conservation in Indian River Lagoon visitor centers

In the most recent decades, there has been extensive loss of seagrasses within the Indian River Lagoon estuary on the eastern coast of Florida. This decline poses a significant threat to the ecological function of the ecosystem, as well as to the social and economic wellbeing of the surrounding communities. Stakeholder buy-in and engagement with conservation initiatives is a critical component of lagoon-wide seagrass restoration and management efforts. Visitor centers, such as zoos, aquarium, and nature centers, can play a key role in increasing knowledge of environmental issues and facilitating behavior change among stakeholders. This capstone project included a 2-phase front-end evaluation to provide recommendations for the network of visitor centers within the region to increase messaging impact and buy-in for seagrass conservation efforts. The first phase involved a content analysis conducted at 11 facilities to understand current messaging strategies. The second phase was a visitor survey conducted at Brevard Zoo in Melbourne, Florida that sought to understand visitors' beliefs and prior knowledge about seagrasses, as well as conduct a pilot-study to compare the impact of various messaging approaches. Combined, these two evaluation efforts helped to inform a set of recommendations to improve future messaging. While this project served as an important first step in improving messaging impact, continued and on-going evaluation efforts will undoubtedly be needed to help

leverage the impact of visitor centers in their efforts to help secure a more sustainable future for seagrasses in the Indian River Lagoon.

Corresponding e-mail address: akdurham@gmail.com

© Copyright by Amy Durham Shea
March 22, 2023

Table of Contents

Introduction

The Indian River Lagoon is an estuary spanning 156 miles of Florida's Atlantic coast, bordering Volusia, Brevard, Indian River, St. Lucie, and Martin counties. Over 4,000 species of plants and animals spend at least part of their lives in the lagoon, (Indian River Lagoon National Estuary Program, 2019), including 7 species of seagrasses (Dawes et al., 1995). Seagrasses provide multiple ecosystem services, including nutrient cycling (Costanza et al., 1998), stabilization of sediments (Hemminga & Duarte, 2000), and protection from shoreline erosion (Ondiviela et al., 2014), as well as support the lagoon's high level of biodiversity (Virnstein et al., 1983). While these submerged aquatic plants once thrived in the Indian River Lagoon, there has been extensive seagrass loss throughout the length of the lagoon in the most recent decades (Indian River Lagoon National Estuary Program, 2019). This loss is attributed to numerous interconnected factors, including decreased habitat suitability due to poor water quality (Indian River Lagoon National Estuary Program, 2019; Lapointe et al., 2020). The loss of seagrasses in the Indian River Lagoon could have far reaching impacts for the species that live in and depend on the lagoon ecosystem, as well as the surrounding community. (See Appendix for a visual overview summary of seagrasses in the Indian River Lagoon, causes of seagrass loss, and proposed management solutions).

Visits to informal science learning centers, including zoos, aquariums, and nature centers (hereafter collectively referred to as "visitor centers"), are one of many ways that the public learns about environmental topics (Falk, 2005). There are numerous visitor centers located in close proximity to the Indian River Lagoon that feature interpretive exhibits and experiences designed to inform guests about seagrasses within the estuary. While these

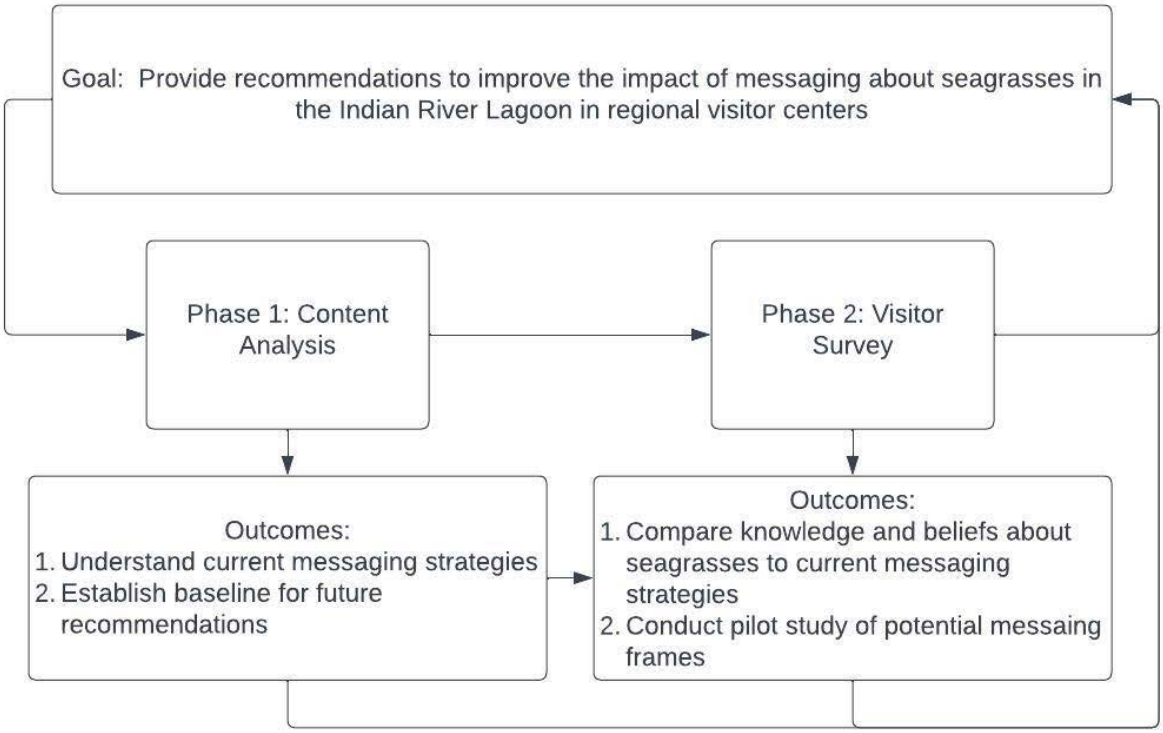
facilities' specific goals and approaches vary, their missions all include educating guests about local environmental issues and promoting awareness of conservation actions in some capacity. While some of these facilities focus primarily on the Indian River Lagoon and others address a broader scope of environmental topics, this network of visitor centers can help to inform their audiences about the role of seagrasses in the lagoon, impact their attitudes towards seagrass conservation efforts (Ballantyne & Packer, 2005; Pearson et al., 2014; Swim et al., 2017; Adelman et al., 2020), and potentially increase their likelihood or willingness to take conservation action (Ballantyne & Packer, 2005; Pearson et al., 2014; Swim et al., 2017).

Serving as a front-end evaluation, this project examined current messaging in visitor centers across the region and sought to better understand visitors' knowledge and beliefs about seagrasses in the Indian River Lagoon in order to provide recommendations to improve conservation messaging. Front-end evaluations can play a valuable role in facilities such as these in creating more impactful exhibits and experiences by providing insight into visitors' prior knowledge, values, and beliefs before costly and time intense design and creation of interpretive elements takes place (Miles & Clarke, 1993; Hayward, 2014). This project took a two-fold approach to front-end evaluation, as outlined in Figure 1. First, a content analysis helped establish baseline information about current messaging strategies. Then, a visitor survey conducted at Brevard Zoo in Melbourne, FL was used to compare current messaging strategies to visitors' prior knowledge and beliefs about seagrass and conduct a preliminary comparative test of various messaging approaches. Combined, this data helped to guide the creation of a set of recommendations aimed at improving the impact of future interpretive exhibits at the Brevard Zoo and other facilities working to educate visitors about seagrasses in the Indian River

Lagoon and increase buy-in for seagrass conservation action.

Figure 1

Diagram of evaluation approach



Note. This project aims to provide recommendations to improve impact of messaging about seagrasses in the Indian River Lagoon through a 2-phase front-end evaluation.

Background and Literature Review

Seagrasses in the Indian River Lagoon

Seagrasses, such as the ones shown in Figure 2, are flowering plants uniquely adapted to live fully submerged in brackish and salt water. They are found in shallow coastal and estuarine

waters across the globe on all continents except Antarctica (Hemminga & Duarte, 2000). Seagrasses require specific environmental conditions and are particularly sensitive to environmental changes. Due to their environmental sensitivity, they can serve as indicators of the overall health of the ecosystem in which they live (Orth et al., 2006). Seagrasses are unable to grow in extremely low or high salinities, and most species can only live in sandy or muddy sediments with low amounts of organic matter (Hemminga & Duarte, 2000). They require shallow depths and low turbulence, as enough sunlight for adequate photosynthesis must be able penetrate the water column to facilitate growth.

Figure 2

Example of seagrasses in Florida

Note. From *A seagrass meadow. Florida Keys National Marine Sanctuary* [Photograph], by Heather Dine, 2010, Flickr (https://www.flickr.com/photos/noaaphotolib/5077876455). CC BY 2.0.

Seagrasses provide a multitude of ecological, economic, and cultural ecosystem services (Hemminga & Duarte, 2000; Orth et al., 2006; McHenry et al., 2021;). Seagrasses can be considered a "coupled ecological-social system," (Cullen-Unsworth et al., 2014), with the loss of seagrasses having profound implications across the globe on human wellbeing. Seagrasses and algae beds have an estimated global value of $3.8 trillion, with the majority of their calculated value attributed to their role in nutrient cycling (Costanza et al., 1998). When seagrasses die, the nitrogen, phosphorus, and carbon in their leaves is buried and stored in the sediment. Partially as a result of this process, seagrasses are instrumental in global carbon sequestration (Hemminga & Duarte, 2000). In addition, seagrasses improve overall water quality. They produce oxygen through their photosynthetic processes, absorb nutrients from the water, and stabilize fine sediments and other particles that may otherwise be suspended in the water column (Hemminga & Duarte, 2000). Due to their ability to reduce the velocity of moving water and attenuate waves, seagrasses help protect shorelines from erosion and flooding due to sea level rise and strong storms (Ondiviela et al., 2014).

Seagrasses also have a critical role in supporting global biodiversity (McHenry et al., 2021). A greater abundance and diversity of organisms is found in seagrass beds than in adjacent non-vegetated areas (Hemminga & Duarte, 2000). Seagrasses serve as primary producers and provide a valuable food source for herbivorous animals. These species may consume both the roots and blades of the seagrasses, as well as algae that frequently grow on seagrass leaves. Seagrasses are widely associated with high populations of juvenile animals (Hemminga & Duarte, 2000), and both commercially and recreationally important fisheries species depend on seagrass beds as nursery, foraging, and/or breeding areas (Unsworth et al.,

2019; Hemminga & Duarte, 2000). As a result, seagrasses support food security for many coastal communities (Cullen-Unsworth et al., 2014). Seagrasses are also important feeding grounds for culturally significant, charismatic, and endangered species, in turn supporting opportunities for ecotourism and providing important sources of household income. These species include green sea turtles (*Chelonia mydas*) (as shown in Figure 3), West Indian manatees (*Trichechus manatus*), and dugongs (*Dugong dugon*) (Cullen-Unsworth et al., 2014).

Figure 3

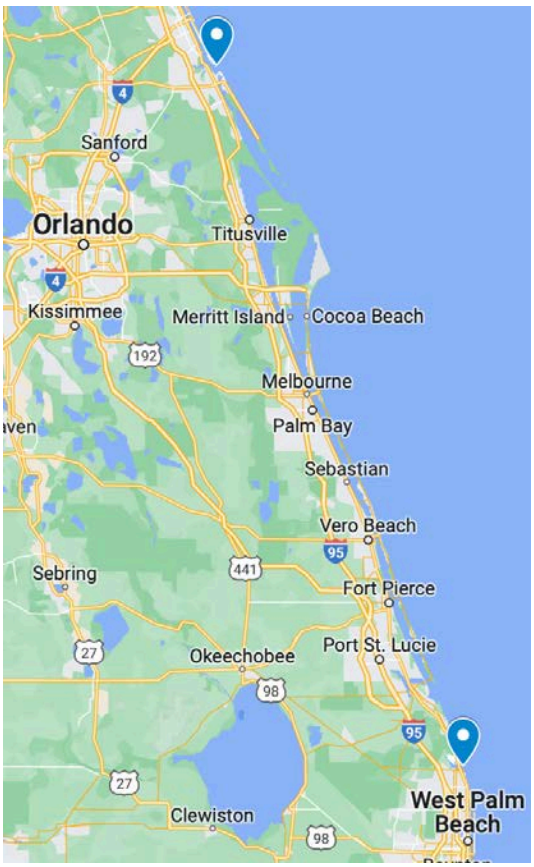
Green sea turtle eating seagrasses

Note. From *Green sea turtle grazing seagrasses* [Photograph], by P. Lindgren, 2013, Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Green_Sea_Turtle_grazing_seagrass.jpg). CC BY-SA 3.0.

Historically, the Indian River Lagoon, shown on the map in Figure 4, provided ideal habitat for seagrass due to its suitable salinity and average depth of 4 feet (Dawes et al., 1995). All seven species of seagrasses native to the Caribbean region once grew in the Indian River Lagoon. These species include turtle grass (*Thalassia testudinium*), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), star grass (*Halophila engelmannii*), paddle grass (*Halophila decipiens*), and widgeon grass (*Ruppia maritima*), as well Johnson's seagrass (*Halophila johnsonii*), a species endemic to Florida's east coast (Dawes et al., 1995). According to long-term monitoring efforts beginning in the 1940s, seagrasses in the lagoon typically cycle through gradual periods of decline in density and coverage followed by periods of recovery (Morris & Virnstein, 2004). However, there has been widespread loss of seagrasses throughout the Indian River Lagoon since 2011 (Indian River Lagoon National Estuary Program, 2019; Lapointe et al., 2020; Morris et al., 2022). During this time period, estimates of seagrass loss range from approximately 50% (Morris et al., 2022) to 95% in portions of the lagoon (Lapointe et al., 2020). The recent rate and extent of loss has raised new concerns about the ecological function of the lagoon and the ability of seagrasses to regrow (Morris et al., 2022).

Figure 4

Map of the Indian River Lagoon, Florida



Note. The Indian River Lagoon stretches 156 of Florida's Atlantic coast as shown in this map from Google (2023a). It begins at Ponce Inlet at the north and ends at Jupiter Inlet in the south.

Widespread loss of seagrasses in the Indian River Lagoon is attributed to a multitude of interconnected environmental factors (Morris et al., 2021). Poor water quality, and in particular high levels of nutrient pollution, has been identified as one of the primary drivers (Indian River Lagoon National Estuary Program, 2019; Lapointe et al., 2020). Management agencies and researchers have been aware of deteriorating habitat suitability in the lagoon for seagrasses since the 1970s (Lapointe et al., 2020). Large alterations in salinity, hydrology, and nutrient input began in the early 1900s when an extensive series of drainage canals designed to make south Florida more suitable for agricultural development greatly expanded the Indian River

Lagoon watershed (Sime, 2005; Osborne, 2016). In addition, the region surrounding the Indian River Lagoon began experiencing rapid urban growth in the 1950s, coupled with poor sewage and wastewater infrastructure (Osborne, 2016; Lapointe et al., 2020). Today, nutrients continue to enter to the lagoon from agricultural runoff from inland areas, stormwater runoff, leaking septic systems, sewage spills, and more (Indian River Lagoon National Estuary Program, 2019). Over a century of increasing amounts of nutrients entering the lagoon have resulted in a series of large-scale algae blooms in recent years. These blooms effectively block sunlight from reaching the seagrasses below and create hypoxic conditions as they decay (Han & Lui, 2014), resulting in extensive seagrass loss as has been occurring in the Indian River Lagoon since the first such bloom in 2011 (Osborn, 2016; Indian River Lagoon National Estuary Program, 2019).

The loss of seagrass forms a positive feedback loop preventing regrowth through a number of mechanisms (Morris et al., 2021; Morris et al., 2022). The loss of seagrasses destabilizes sediments. These sediments are re-suspended in the water column, blocking sunlight from reaching remaining seagrasses (Dawes et al., 1995; Morris et al., 2022). As seagrasses die, the nutrients that were once stored with their tissues become available to other primary producers, including algae. This process can fuel additional algae blooms, which both contributes to additional seagrass loss and prohibits seagrass regrowth (Morris et al., 2022). Further compounding these issues is a layer of “muck,” or sediment composed of detritus from urban runoff, in large portions of the bottom of the lagoon. Muck is an unsuitable substrate for seagrass growth and is easily re-suspended in the water column, leading to additional loss of water clarity (Morris & Virnstein, 2004).

The extensive loss of seagrasses in the Indian River Lagoon poses a significant threat to the ecological function of the ecosystem, as well as to the social and economic wellbeing of the surrounding communities. Seagrasses were, at least historically, the primary producer of the lagoon ecosystem, supporting thousands of animal species that spend all or part of their lives in the watershed or adjacent near and offshore areas (Osborn, 2016; Indian River Lagoon National Estuary Program, 2022c). Like seagrasses across the globe, seagrass beds within the lagoon have a higher density of juvenile fish species and macro-invertebrates than sandy bottom areas (Virnstein et al., 1983). These organisms play important roles in ecosystem function and the lagoon's trophic structure. Most fishes in the Indian River Lagoon rely on seagrasses for habitat or food for at least part of their lives (Indian River Lagoon National Estuary Program, 2022c). These fishes include recreationally and commercially important fisheries species (Gilmore et al., 1981), both of which are important to the regional economy (East Central Florida Regional Planning Council & Treasure Coast Regional Planning Council, 2016; Florida Fish and Wildlife Conservation Commission, 2022). Charismatic species, including green sea turtles, West Indian manatees, Atlantic bottlenose dolphins (*Tursiops truncatus*), and numerous bird species, such as brown pelicans (*Pelecanus occidentalis*) and osprey (*Pandion haliaetus),* also rely either directly or indirectly on seagrass beds. Manatees in the Indian River Lagoon depend on seagrasses as a primary food source (Allen et al., 2022), while dolphins and birds feed on fish reliant on seagrasses (Gilmore et al., 1981; Greller et al., 2021). In addition to their ecological importance, these species also have significant cultural and economic importance in the Indian River Lagoon region. Ecotourism activities such as manatees and dolphin spotting cruises and bird watching activities are driven by the presence of these and other charismatic species

(Indian River Lagoon National Estuary Program, 2019). In total, the Indian River Lagoon supports an estimated $7.6 billion of economic output each year (East Central Florida Regional Planning Council & Treasure Coast Regional Planning Council, 2016). This value includes the values of finfish and shellfish industries, recreational boating and fishing, tourism and other leisure activities, and over 70,000 jobs. Much of this economic output depends either directly or indirectly on the sustainable management of seagrasses to some extent.

Lagoon-wide management is complex and multi-faceted, with management jurisdiction falling under numerous federal, state, and local entities, including two state water management districts, seven counties, and approximately 40 municipalities (Florida Department of Environmental Protection, 2019; Indian River Lagoon National Estuary Program, 2019). The Indian River Lagoon National Estuary Program, which coordinates lagoon-wide management efforts across all levels, has identified the restoration and sustainable management of seagrasses as a critical component of its Indian River Lagoon Comprehensive Conservation and Management Plan (2019). As part of ongoing lagoon management work, a wide-range of seagrass conservation and restoration projects has already been implemented. These projects include efforts to improve water quality by reducing further nutrient input and removing legacy nutrient loads, thus increasing habitat suitability for seagrasses. Other projects focus on seagrasses restoration through replanting initiatives (Indian River Lagoon National Estuary Program, 2019; Tetra Tech, Inc., 2022). In addition to these larger-scale management projects, individual-level actions are promoted throughout the region to help reduce nutrient pollution and improve water quality, thus improving habitat suitability for seagrasses. Many organizations provide lists of at-home actions that area residents can do to help protect,

preserve, and restore the Indian River Lagoon, including the Indian River Lagoon National Estuary Program (2022a). Suggested actions focus on a broad array of topics, ranging from lawn care to septic to sewer upgrades and sewer line repair.

Communication and Visitor Centers as Drivers for Environmental Learning and Seagrass Conservation

Stakeholder buy-in and engagement in conservation action is critical to the successful sustainable management of seagrasses in the Indian River Lagoon (Indian River Lagoon National Estuary Program, 2019). Improved communication with stakeholders is one of the Indian River Lagoon National Estuary Program's target actions to restore the Indian River Lagoon (Indian River Lagoon National Estuary Program, 2019, 2022b). There are, however, significant barriers to effectively communicating with stakeholders about seagrass conservation and management. First, the public may have a generally poor understanding of environmental issues that are "invisible" and complex (Pearson et al., 2014). Seagrasses and the ecosystem services they provide are less well known than other coastal ecosystems (Orth et al., 2006; Duarte et al., 2008), and there are a multitude of complex factors that have collectively contributed to both nutrient pollution and seagrass loss in the lagoon. Many of these contributing factors are "invisible" to stakeholders, such as leaking sewer pipes or septic systems.

Communication issues may be further compounded by variations in stakeholder and management concerns along the length of the lagoon. The Indian River Lagoon's watershed is expansive, covering over 2,000 square miles of land where over 1.6 million people reside (Indian River Lagoon National Estuary Program, 2019). Many residents do not live in direct proximity to lagoon, and the population in this area is diverse with a variety of economic

interests (Office of Economic and Demographic Research, 2022). The majority of the Indian River Lagoon watershed falls under the jurisdiction of the St. Johns River Water Management District. The most southern portion, however, falls under the jurisdiction of the South Florida Water Management District (Florida Department of Environmental Protection, 2019). This district also manages the Florida Everglades. As a result, the management of the Indian River Lagoon is tied to larger statewide management and restoration concerns, including efforts to restore the Florida Everglades (Osborn, 2016).

The public learns about environmental topics from a wide range of sources, including visits to informal science education centers (i.e., visitor centers for the purpose of this project) (Falk, 2005). Learning in these types of facilities is different from the learning that occurs in a formal school setting in that participation is generally voluntary and learning is self-directed (Falk & Dierking, 2000; National Research Council, 2009). Visitor centers provide opportunities for in-depth exploration of topics based on personal interests or motivation, and there is growing recognition of the role of these facilities in learning about environmental topics (Falk, 2005). Studies have shown that visits to these types of facilities have the potential to impact visitors' knowledge and attitudes about environmental issues (Ballantyne & Packer, 2005; Pearson et al., 2014; Swim et al., 2017; Adelman et al., 2020) and their intent or willingness to engage in pro-environmental behaviors (Ballantyne & Packer, 2005; Pearson et al., 2014; Swim et al., 2017).

Exhibits and experiences in visitor centers are often designed to be interpretive in nature. Interpretation is a form of communication that is "purposeful" and that "facilitates meaningful, relevant, and inclusive experiences that deepen understanding, broaden

perspectives, and inspire engagement with the world around us" (National Association of Interpretation, n.d.). Interpretation does more than relay factual information. It aims to foster the formation of meaningful emotional or intellectual connections to the subject, as information is presented in a way that is easily understood as and personally relevant to the audience (Ham, 1992; Brochu & Merriman, 2015). Successful interpretive elements act as a springboard for the audience to think more deeply about the subject at hand (Ham, 1992; Brochu & Merriman, 2015).

Framing is a communication tool in which aspects of a subject are purposefully and strategically emphasized or deemphasized to influence buy-in (Chong & Druckman, 2007, Van Leuvan et al., 2022). The way that information is framed in interpretive exhibits and experiences can influence how visitors perceive and react to information presented (Swim et al., 2017), and the strategic use of frames can have a significant influence on decision-making (Tversky & Kahnemen, 1981; Hardisty et al., 2010; Van Leuvan et al., 2022). Messages may be framed to highlight a gain or benefit expected from engaging in an action or loss or cost resulting from an action or inaction (Cheng et al., 2011; Warner et al., 2015; Ropret Homar & Knežević Cvelbar, 2021; Dai et al., 2022). Current studies show mixed efficacy when gain and loss frames in environmental messaging are compared (Cheng et al., 2011; Ropret Homar & Knežević Cvelbar, 2021). However, loss frames appear to be generally more effective than gain frames. This finding is consistent with broader studies on framing and human decision making indicating that people tend to be risk adverse when making decisions (Cheng et al., 2011; Ropret Homar & Knežević Cvelbar, 2021). A number of factors may impact whether a gain or loss frame is more effective, including the level of risk involved in action or inaction (Cheng et

al. 2011), provocation of positive or negative emotions, and perceived feasibility of the desired outcome (Ropret Homar & Knežević Cvelbar, 2021). Frames may focus on different types of benefits or losses that may be derived from action or inaction, including financial (e.g., cost of inaction, benefit of economic development), social (e.g. environmental justice, national security), personal (e.g., food security, health), or environmental (e.g., climate resilience) (Warner et al., 2015; Van Leuvan et al., 2022). While framing can be a valuable communication tool, variation in how individuals respond to a given communication frame are important to consider. Multiple factors may impact how various audience members respond to different messaging frames, including underlying values (Bolderdijk et al., 2013; Graham & Abrahamse, 2017) and self-constructs (Dai et al., 2022).

When developing new interpretive exhibits and experiences, front-end evaluations can help facilities increase the impact of their interpretive elements and meet desired communication goals. Front-end evaluations occur early in the process of interpretive planning and are key in understanding visitors knowledge, experiences, and attitudes or beliefs about a topic, all of which are key in the successful design of impactful exhibits and experiences (Miles & Clarke, 1993; Hayward, 2013). Front-end evaluations may help identify misconceptions visitors may have about a topic, clarify the desired outcome of an exhibit, develop a clear scope of what needs to be communicated, and determine how visitors may react to different types of exhibits or messaging approaches (Miles and Clarke, 1993).

Study Problem and Objectives

Numerous visitor centers located in the counties along the Indian River Lagoon aim to educator visitors about seagrasses in the Indian River Lagoon and conservation actions that can

be taken to protect and restore this important natural resource. The purpose of this front-end evaluation of seagrass messaging, conducted in part at Brevard Zoo in Melbourne, FL, was to provide insight into messaging strategies and approaches that could help the zoo and other facilities in the region create more impactful interpretive elements about seagrasses and seagrass conservation in the Indian River Lagoon. This evaluation sought to answer the following questions:

1. What messaging strategies are currently in use at visitor centers?
2. What do visitors already know and believe about seagrasses and seagrass conservation in the Indian River Lagoon?
3. In what ways do visitors' knowledge and beliefs about seagrasses align or not align with current messaging strategies?

In addition, this evaluation included a pilot-study to gain preliminary understanding of how various messaging frames may impact visitors' knowledge about seagrasses, their perceived importance of the conservation of seagrass in the Indian River Lagoon, and their likeliness to engage in conservation action. In particular, this evaluation focused on gain and loss frames (Cheng et al., 2011; Warner et al., 2015; Ropret Homar & Knežević Cvelbar, 2021; Dai et al., 2022) for multiple ecosystem services provided by seagrasses.

Methods and Data Collection

This front-end evaluation was conducted in two phases. The first phase included a content analysis to determine which messaging strategies were currently in use at visitor centers. The second phase was comprised of a visitor survey that aimed to understand visitors' pre-existing knowledge and beliefs about seagrasses in the Indian River Lagoon as compared to

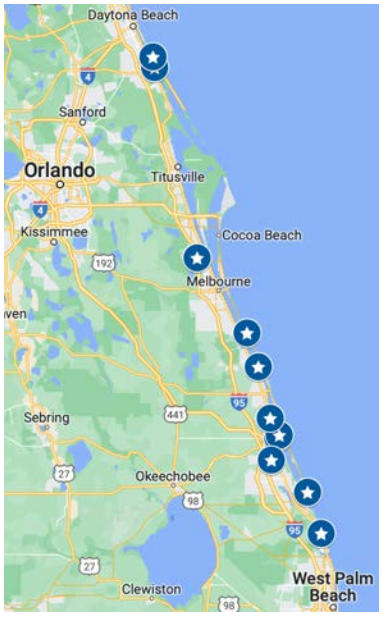
current messaging strategies, as well as conduct a pilot-study to compare the impact of various potential messaging frames.

Phase 1: Visitor Center Interpretive Elements Content Analysis

Eleven visitor centers were visited during normal operating hours to conduct a content analysis of seagrass-related interpretive elements over a three-month period. Facilities were identified using a Google search for “Indian River Lagoon,” “nature center,” “aquarium,” and “zoo” in Volusia, Brevard, Indian River, St. Lucie, and Martin counties, FL. Approximate location of included facilities are shown in Figure 5. In order to ensure a representative sample of seagrass messaging approaches across the region, representation from facilities in all five counties located along the length of the lagoon and those of various sizes and overarching organization (including government-funded, not-for-profit, and academic) were included.

Figure 5

Approximately location of visitor centers included in content analysis.



Note. 11 facilities were included in the content analysis, as shown in this Google Map (2023b). These facilities represented various sizes, overarching organization, and location with representation of facilities from all 5 counties bordering the Indian River Lagoon.

The content analysis included all messaging in interpretive elements accessible and on display to general admission/public visitors to the facility, such as printed signs, exhibits, brochures, and pre-recorded audio-visual elements. All included elements were in publicly accessible areas of the facility, including indoor exhibit halls, outdoor exhibit areas, and walking/hiking trails owned and/or operated by the facility. Information from interpretive staff or volunteers, information only accessible during premium visitor experiences (e.g., behind-the-scenes tours), and any elements created by outside organizations but distributed at the facility (e.g., brochures and informational pamphlets from third party organizations) were not included. In addition, the analysis only included messaging with a specific focus on seagrasses, excluding messaging in which seagrasses were discussed in conjunction with other or multiple lagoon ecosystems (e.g., when messaging listed the combined benefits of seagrasses, oysters, and mangroves to the Indian River Lagoon).

The content analysis took an exploratory, flexible approach, guided by three principle areas of interest:

a. Ecosystem services/benefits of seagrasses in Indian River Lagoon.

b. Loss of seagrasses in the Indian River Lagoon.

c. Conservation actions to protect or restore seagrasses in the Indian River Lagoon in messaging.

Whenever possible, photographs or recordings of materials were taken to assist with coding. Content analysis data was coded with a primary focus on identifying relevant patterns in messaging approaches, and numerical results were assigned to data, when applicable (e.g., X out of Y facilities used a particular approach to messaging) (Maxwell, 2013).

Phase 2: Visitor Survey

A visitor survey was conducted over a period of six weeks at Brevard Zoo. The survey was open to residents of Volusia, Brevard, Indian River, St. Lucie, and Martin counties, FL who were 18 years of age of older. Visitors were actively recruited and asked to participate by scanning a QR code linking to the survey accompanied by a short description of the purpose of the evaluation study. Outside of two questions used to determine eligibility for participation (Do you live in Volusia, Brevard, Indian River, St. Lucie, or Martin county, FL? Are you 18 years of age or older?), no identifying or demographic data was collected. While general zoo visitors were the primary target audience for the survey, there were no screening questions to preclude zoo staff and volunteers from participating in addition to general zoo guests. A small number of staff and volunteers are known to have participated. To ensure a representative sample, the target sample size was between 100-150 visitors, with each tested messaging frame presented to a minimum of 15 visitors (McManus, 1991). An oversight determination submission was made to the Institutional Review Board at Oregon State University to determine if the survey required review as human-subjects research, and the Board concluded that this project was "not human-subjects research" due to the focus on gathering information to make recommendations to improve messaging at regional visitor centers rather than generalizable or theoretical knowledge.

The survey was divided into 3 parts. The first part of the survey sought to understand visitors' prior knowledge and beliefs about seagrasses. Visitors were asked to rank their overall familiarity with seagrasses on a 5-point Likert scale, with 1 being they "strongly disagree" and 5 being that they "strongly agree" with the statement "I am knowledgeable about seagrasses in the Indian River Lagoon," describe why they do or do not believe that seagrasses were important, and select what they believed are the biggest threats to seagrasses in the Indian River Lagoon from a provided list. This list included threats identified during the content analysis, as well as threats that are common to ecosystems in Florida (e.g., invasive species) and those recently in the media (e.g., overgrazing from manatees or other lagoon species).

Following these initial questions, visitors were randomly assigned to view 1 of 6 potential seagrass conservation messaging frames presented on a standardized sign template. The template included a title and representative photo, as shown in Figure 6. Tested frames included a gain that could occur from engaging conserving seagrasses and a loss that could occur as a result of not conserving seagrasses for each of three ecosystem services provided by seagrasses in use at visitor centers during the content analysis. These ecosystem services included the support of commercial and recreational fishing, support of the manatee population, and protection from shoreline erosion. The tested messaging frames were:

a. Fisheries Gain Frame: If we protect seagrasses, we help safeguard seagrasses in the Indian River Lagoon.
b. Fisheries Loss Frame: If we do not protect seagrasses, we risk losing fish populations in the Indian River Lagoon.

c. Manatee Gain Frame: If we protect seagrasses, we help safeguard manatees in the Indian River Lagoon.

d. Manatee Loss Frame: If we do not protect seagrasses, we risk losing manatees in the Indian River Lagoon.

e. Shoreline Protection Gain Frame: If we protect seagrasses, we help safeguard homes and businesses along our shorelines.

f. Shoreline Protection Loss Frame: If we do not protect seagrasses, we risk damage to homes and businesses along our shorelines.

Figure 6

Gain and loss messaging frame templates developed for evaluation in the survey

Note. Messaging templates used in the visitor survey from left to right and top to bottom: Fisheries Gain, Fisheries Loss, Manatee Gain, Manatee Loss, Shoreline Protection Gain, Shoreline Protection Loss.

After viewing the frame, visitors were asked whether they agreed or disagreed to a series of statements on a 5-point Likert scale where 1 was “strongly disagree” and 5 was “strongly agree” in response to the messaging frame (i.e., “sign”) they viewed. These statements included:

a. The loss of seagrasses in the Indian River Lagoon directly impacts me.

b. Protecting seagrasses in the Indian River Lagoon is important to me.

c. The information on this sign is relevant to me.

d. The information on this sign makes me more likely to take action to protect seagrasses in the Indian River Lagoon.

e. I learned something I did not know from reading this sign.

The impact of messaging frames were evaluated and compared in three ways, including:

a. An individual level comparison of the impact of each frame against the impact of other individual frames.

b. A collective comparison of the impact of gain versus loss frames.

c. A collective comparison of the impact of frames by topic (i.e., fisheries frames, manatee frames, and shoreline protection frames).

In the final part of the survey, visitors were asked two additional questions about their general beliefs about seagrasses in the Indian River Lagoon. First, they were asked to select the benefits (i.e., ecosystem services) of seagrass that are most important to them from a list of ecosystem services provided by seagrasses identified during the content analysis. Then, they were asked to select the actions that they would be most willing to take to protect seagrasses. Options provided were based on the Indian River Lagoon National Estuary Program's "Be Lagoon Friendly" list of individual-level household-based actions (Indian River Lagoon National Estuary Program, 2022a). While aimed at understanding visitors' prior knowledge and beliefs about seagrasses like the first part of the survey, these questions were asked after viewing the messaging frame to avoid priming visitors' thinking and reducing bias in response to the messaging frames.

All data was analyzed qualitatively to identify trends in visitors' beliefs and responses to messaging frames. For the purposes of understanding impact of messaging frames, only responses of "somewhat agree" and "strongly agree" were considered as having a positive impact.

Results

Phase 1: Visitor Center Interpretive Element Content Analysis

Visitor Centers' current messaging about ecosystem services.

Of the 11 visitor centers visited, 10 facilities' interpretive elements included information about one or more ecosystem services provided by seagrasses, such as in the interpretive elements shown in Figure 7. The number of ecosystem services included in messaging ranged from 0 to 9 with an average of 4.1 ecosystem services per facility. Seven facilities provided information about more than one ecosystem service. In the facility that did not include any messaging about ecosystem services of seagrass, messaging was limited to the presence of seagrasses in the lagoon, along with other lagoon habitats such as oyster reefs and mangroves. There was a manatee depicted in their seagrasses exhibit, but there was no accompanying explanation about the connection between manatees and seagrasses. In addition to highlighting the ecosystem services provided by seagrasses, 4 facilities included messaging about the environmental sensitivity of seagrasses and its potential to serve as indicator of overall lagoon health.

Figure 7

Interpretive elements in visitor centers addressing the ecosystem services of seagrasses

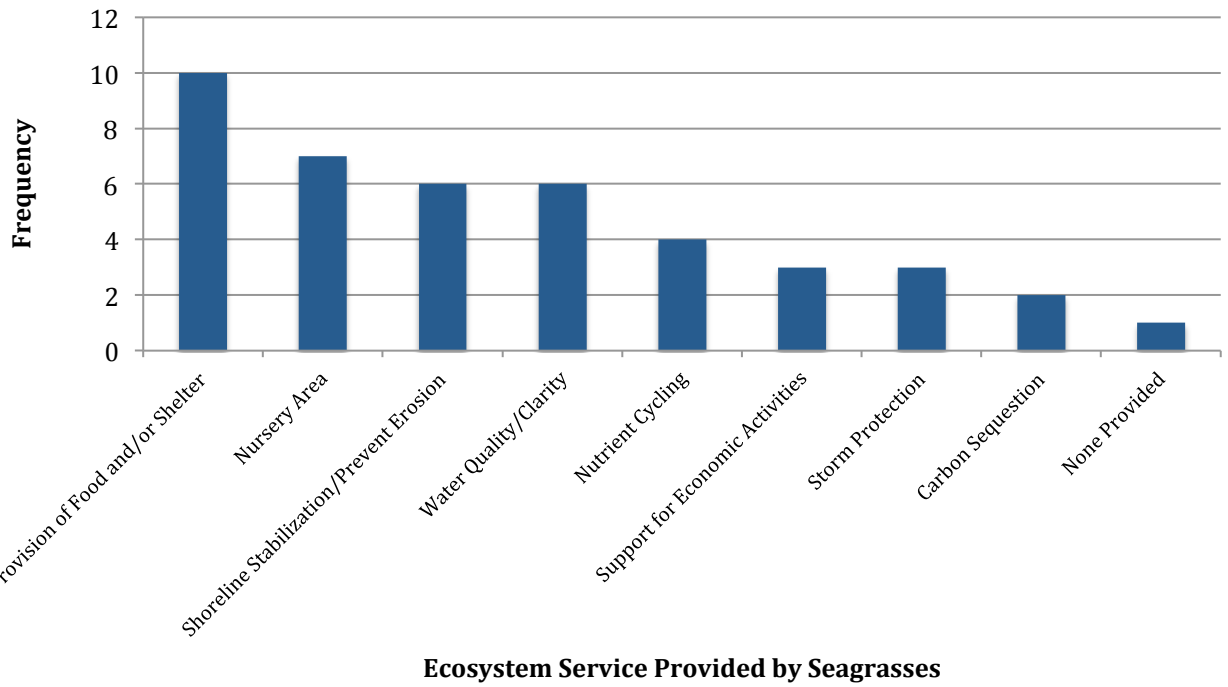
Note. Examples of interpretive elements addressing the ecosystem services provided by seagrasses. Ecosystem services are presented in a bulleted or list-like format.

The most common ecosystem service of seagrasses included in messaging was the role of seagrasses in supporting biodiversity through the provision of food and/or shelter, as seen in Figure 8. All facilities that provided information about the ecosystem services of seagrasses included some information about this topic. Further, all of these facilities included supporting information about 1 or more specific species or groups of species that depend on seagrasses in some way. The most frequently mentioned group of species was commercial and/or recreational fisheries species, including various fishes, shrimp, lobster, crab, and bivalves. Messaging about the role of seagrasses in supporting fisheries appeared in 9 facilities. In addition, facilities frequently shared information about the role of seagrasses in supporting one

or more charismatic lagoon species. The most commonly included species were manatees (n=6) and sea turtles (n=6). Other species highlighted included seahorses (n=3), unspecified mammals (n=1), and birds (n=1). In addition to the role seagrasses play in supporting biodiversity through provision of food or shelter, other ecosystem services of seagrasses addressed in messaging included the role of seagrasses as a nursery area for juvenile species (n=7), shoreline stabilization and/or prevention of erosion (n=6), support of general water quality or clarity (n=6), nutrient cycling (n=4), support for economic activities such as supporting ecotourism (n=3), storm protection (n=3), and carbon sequestration (n=2).

Figure 8

Ecosystem services of seagrasses in the Indian River Lagoon in current visitor center messaging strategies

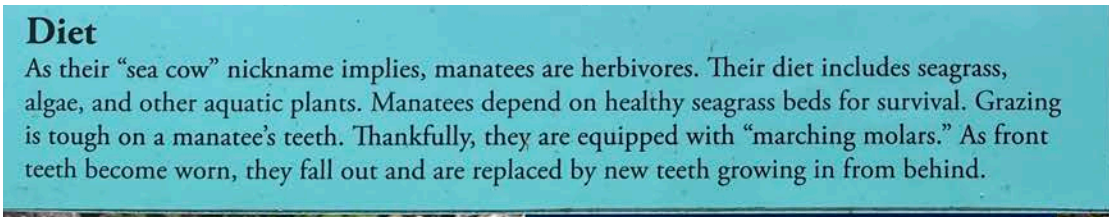


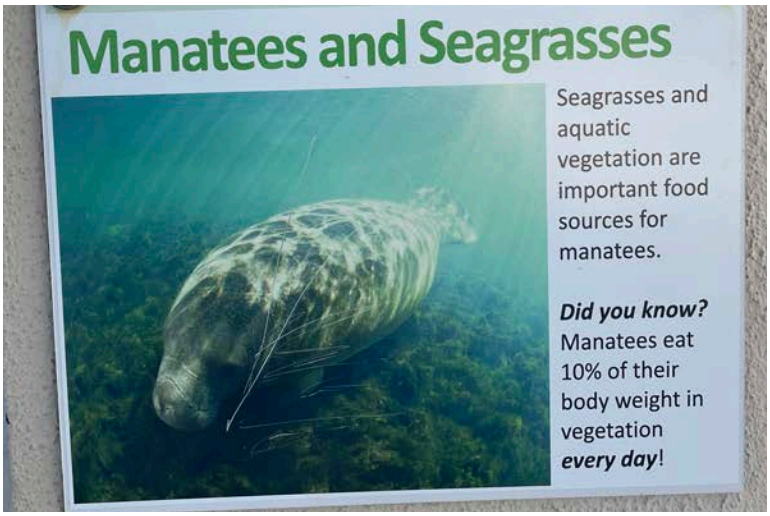
Note. The ecosystem services provided by seagrasses in the Indian River Lagoon included in interpretive elements based on a messaging content analysis of interpretive elements at 11 regional visitor centers. Number of ecosystem services provided by seagrasses included in messaging at a facility ranged from 0 to 9 with a mean of 4.1 ecosystem services included in messaging per facility. Analysis included all interpretive elements accessible and on display to all general admission/public visitors to the facility, such as printed signs, exhibits, brochures, and pre-recorded audio-visual elements.

Information about ecosystem services provided by seagrasses was most frequently presented in a list-like format, with multiple ecosystem services presented in a bulleted list or a single sentence, as shown in the interpretive elements shown Figure 7. There was often little to no additional explanation or contextualization. For example, seagrasses were often presented as one of several possible food sources manatees, without any additional information regarding the relative importance of seagrasses as food source, as shown interpretive elements in Figure 9. Similarly, when addressing the importance of seagrasses in supporting fisheries species, there was often no explanation of the importance of cultural or historical importance of fisheries or the value of fisheries in the regional economy. This same pattern was common even when addressing complex ecological processes, such as nutrient cycling. Two of the 3 facilities that provided information about nutrient cycling did not provide additional context or explanation for visitors who may be unfamiliar with this process. These facilities instead simply listed “nutrient cycling” or “removing nutrients” among a list of the ecosystem services provided by seagrasses.

Figure 9

Interpretive elements in visitor centers addressing the importance of seagrasses for manatees





Note. Two examples of interpretive elements that list seagrasses as one possible food source for manatees. Many interpretive elements addressing the relationship between manatees and seagrasses did not provide any contextualization or quantification of the importance of seagrasses as a food source for manatees in the Indian River Lagoon.

Visitor centers' current messaging about seagrass loss.

Ten of the 11 facilities either directly or indirectly addressed loss of seagrasses in the Indian River Lagoon. Eight facilities explicitly stated that seagrasses are declining in the lagoon, and an additional 2 facilities provided information about threats to seagrasses or causes of

seagrass loss in the lagoon without directly stating that seagrasses are in decline. Among those facilities that explicitly addressed the loss of seagrasses within the lagoon, 6 facilities included messaging about loss of seagrass across the lagoon as whole. Two facilities focused on seagrass loss in the geographic region directly adjacent to that facility. While no facilities included information about recovery of seagrasses in the lagoon, 1 facility did have an interpretive element that stated that seagrasses are thriving in the Indian River Lagoon. This same facility, however, included additional information about the scope and causes of seagrass loss in other interpretive elements.

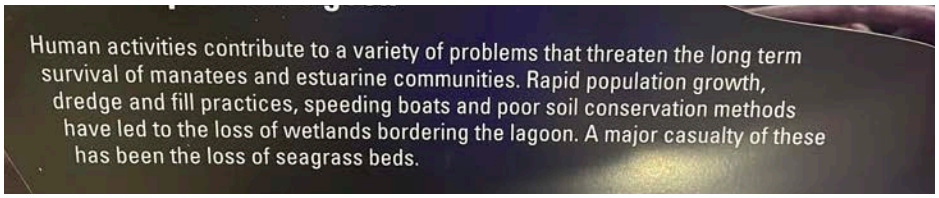
Six of the centers provided quantitative data regarding the scope or scale of seagrass loss in the lagoon. This information, however, was highly variable and sometimes contradictory. One facility included data about the percentage of seagrass lost over the past decade, 2 facilities included data about the number of acres of seagrass coverage lost over several decades, and 1 facility included data on percentage of seagrass lost with no timeframe provided. Two facilities provided data on the percentage of seagrass loss during 1 year (2011). The percentage of seagrass loss cited by these two facilities, however, differed by 15%. The 2 facilities that directly addressed seagrass loss but did not provide quantitative data provided more general statements about seagrass loss, such as seagrasses “vanishing” across the lagoon.

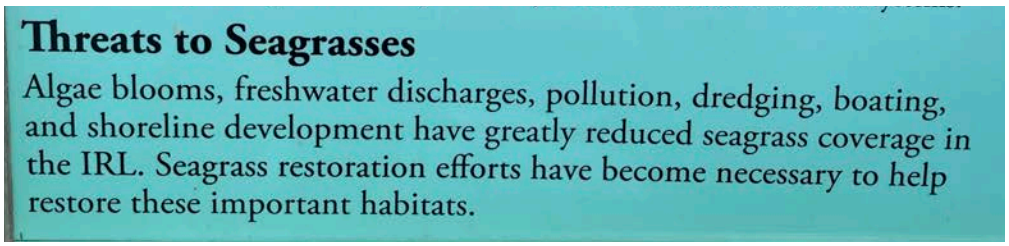
Similar to the approach taken in providing information about the ecosystem services of seagrass, the majority of centers (n=7) provided information about multiple causes of seagrass loss, such as seen in the interpretive elements shown in Figure 10. The number of specific causes of seagrass loss ranged from 0 to 8 with an average of 3 per facility. As shown in Figure 11, the most frequently cited causes of seagrass loss were damage from boat propellers (n=6)

and general water pollution (n=6). While some facilities provided no additional contextualization about the definition of "water pollution," other facilities described or defined water pollution in a variety of ways, including pollution from herbicides and pesticides, runoff, litter, or toxic chemicals. Other causes of seagrass loss in interpretive elements included dredging (n=6), algae blooms (n=4), increased population or development (n=3), nutrient pollution (n=3), salinity changes (n=3), and sediment changes (such as the presence of muck) (n=3). One facility also included messaging about unknown causes of seagrass loss, indicating that more research was needed in order to understand the cause of seagrass loss in the Indian River Lagoon.

Figure 10

Interpretive elements in visitor centers addressing the causes of seagrass loss

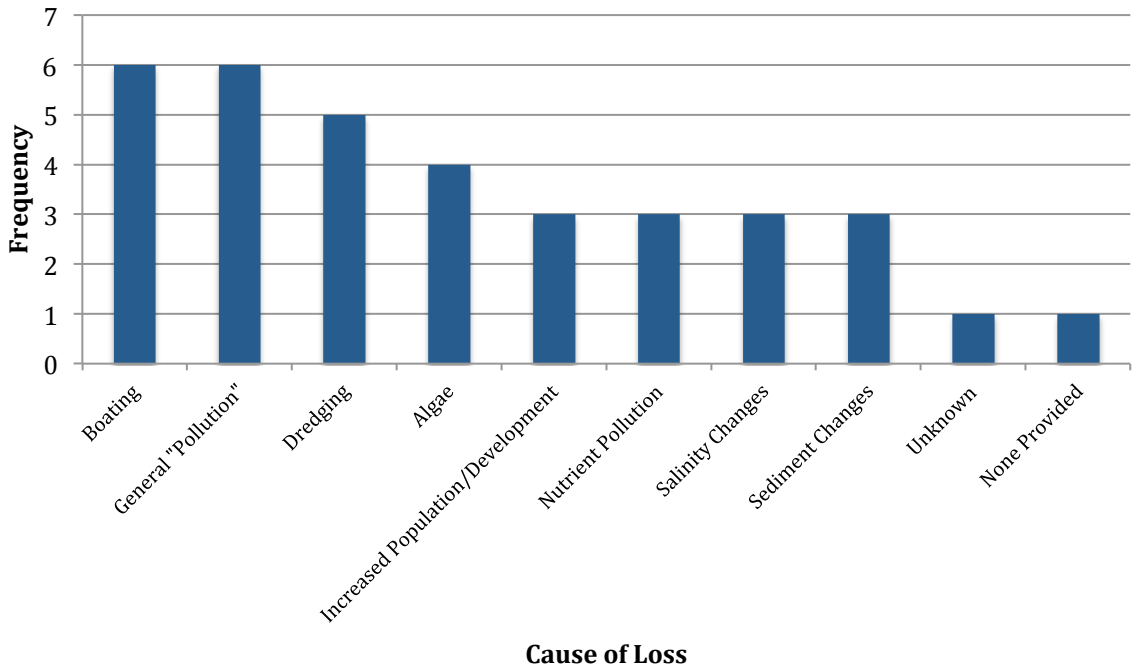




Note. Examples of interpretive elements addressing causes of seagrass loss in the Indian River Lagoon. In both examples, multiple causes are presented with little explanation or contextualization.

Figure 11

Causes of seagrass loss in current visitor center messaging strategies



Note. The causes of by seagrasses in the Indian River Lagoon included in current interpretive elements based on a messaging content analysis conducted at 11 regional visitor centers. Number of causes of seagrass loss included in messaging at a facility ranged from 0 to 8 with a mean of 3 causes included in messaging per facility. Analysis included all interpretive elements accessible and on display to all general admission/public visitors to the facility, such as printed signs, exhibits, brochures, and pre-recorded audio-visual elements.

There was often little contextualization or explanation about the mechanism behind how the issue cited leads to seagrass loss. For example, as can be seen in Figure 10, multiple facilities listed “boats” as a cause of seagrass loss, without any additional explanation about

how or why boating may lead to seagrass loss. Additionally, 4 facilities included information about algae blooms leading to seagrass loss. However, only 2 of these centers included further information to help visitors understand how algae blooms block light from reaching the photosynthetic seagrasses growing on the lagoon floor. Only 1 of these facilities also included information about the role of nutrient pollution in fueling recent large-scale algae blooms. Other facilities provided information about nutrient pollution and its impact on water quality but did not explain why or how water quality impacts seagrasses.

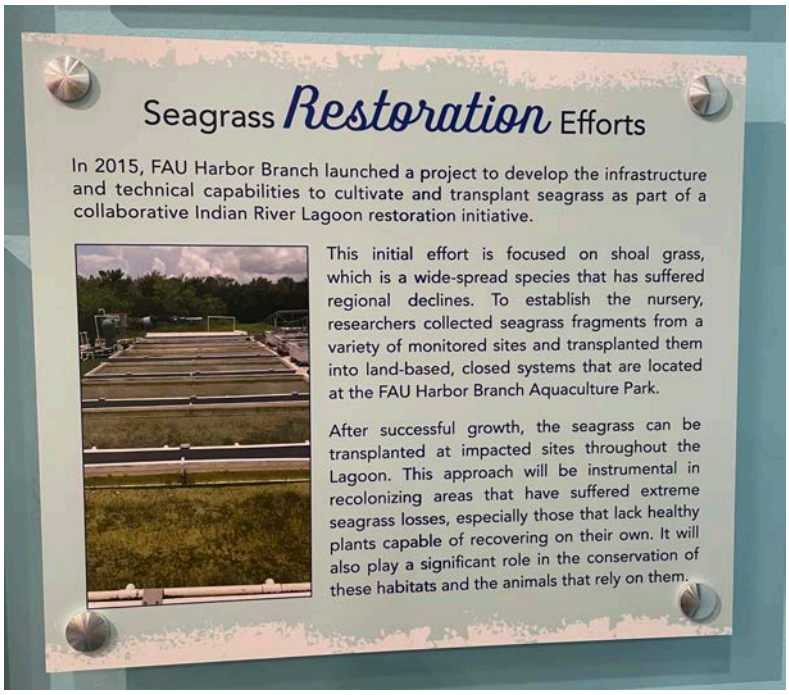
Visitor centers' current messaging about seagrass conservation action.

Ten of the 11 facilities included conservation actions that could be taken to help protect and restore seagrasses in the Indian River Lagoon. As with ecosystem services of seagrasses and causes of seagrass loss, most facilities provided multiple solutions, with an average of 2.5 conservation actions provided per facility. The number of conservation actions included in messaging ranged from 0 to 6, and conservation actions were, again, typically presented in a list-like fashion. The conservation action most frequently included in messaging was replanting seagrasses in the lagoon (n=7), such as in the interpretive element shown in Figure 12, followed by actions related to responsible boating (n=6), such as reducing speed or avoiding shallow areas of the lagoon, as seen in Figure 13. Four facilities included actions related to reducing nutrient pollution (n=4), such as reducing or eliminating fertilizer use (n=4) and picking up pet waste (n=1). Other conservation actions included reducing other sources of water pollution (such as herbicides or pesticides) (n=3), supporting or implementing sustainable development practices such as living shorelines (n=3), additional research (n=2), volunteering with seagrass restoration or monitoring projects (n=2), not walking on/trampling seagrasses (n=2), and

reducing the amount of litter entering the waterway (n=1). Overall, there was a strong emphasis on individual-level actions, with joining volunteer efforts being the most frequently mentioned collective or community-scale solution. Only 1 center directly advocated for supporting conservation legislation, which, in this case, was related to supporting regulations regarding sustainable development practices.

Figure 12

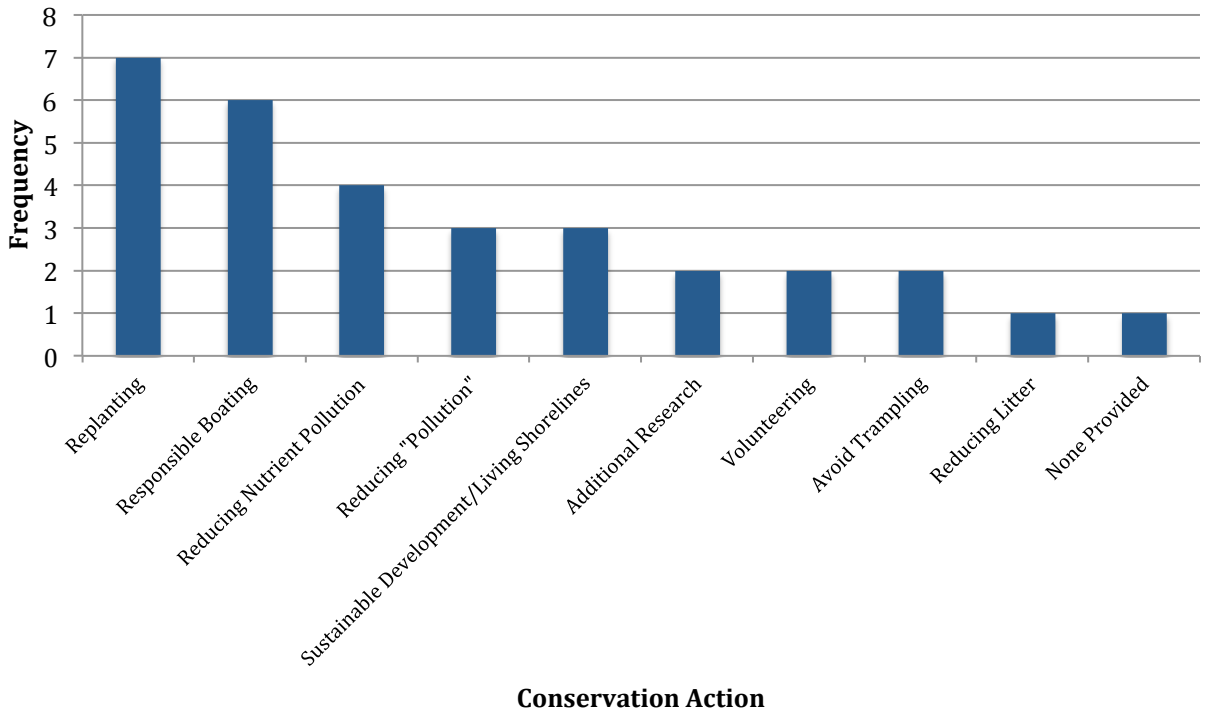
Interpretive element in a visitor center addressing conservation action of replanting seagrasses



Note. Interpretive element addressing replanting of seagrass as a conservation action. Replanting of seagrass was the most frequently included conservation action in messaging included in the content analysis.

Figure 13

Conservation actions to protect seagrasses in current visitor center messaging strategies



Note. The conservation actions to protect and conserve seagrasses in the Indian River Lagoon included in current interpretive elements based on a messaging content analysis conducted at 11 regional visitor centers. Number of conservation actions included in messaging at a facility ranged from 0 to 6 with a mean of 2.5 conservation actions included in messaging per facility. Analysis included all interpretive elements accessible and on display to all general admission/public visitors to the facility, such as printed signs, exhibits, brochures, and pre-recorded audio-visual elements.

As with the ecosystem services of seagrasses and causes of seagrass loss, there was often little explanation or contextualization about how the specific conservation action suggested would directly address seagrass loss. One facility, for example, proposed installing

"living shorelines" as a sustainable development practice. However, there was no explanation of what a living shoreline is or how this action may help protect seagrasses in the lagoon. Another facility included the action of not pouring "hazardous" materials down the drain without any additional definition of what materials are considered hazardous in general or for seagrasses more specifically. There were also multiple facilities in which the causes of seagrass loss and the solutions provided were not clearly connected or were not presented in close proximity to each another. One facility, for example, only addressed pollution from runoff as a cause of seagrass loss but also included responsible boating practices and preventing litter as suggested conservation actions. In a second facility, the causes of seagrass loss were addressed in one indoor exhibit, and conservation actions were provided in a separate outdoor exhibit located along a hiking trail. Further, in this case, the conservation action only addressed responsible boating practices. However, damage from boats was 1 of 4 causes of seagrass loss addressed in the indoor exhibit. This exhibit also included information about dredging, sediment changes, and urban development. No conservation actions were provided to address these additional causes of seagrass loss.

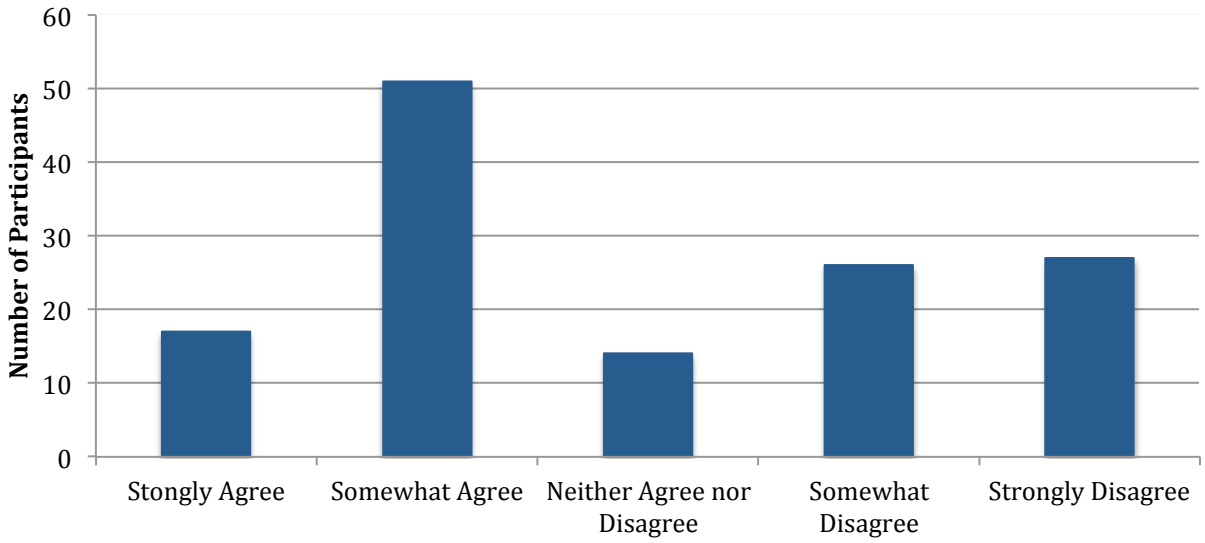
Phase 2: Survey of visitors' knowledge and beliefs about seagrasses and messaging frame impacts

137 people were recruited to participate in the visitor survey and met the criteria of living in Volusia, Brevard, Indian River, St. Lucie, or Martin counties, Florida and being 18 years of age or older. As seen in Figure 14, 50.4% of participants indicated that they believed that they are knowledgeable about seagrasses in the Indian River Lagoon, with 12.6% (n=17) indicating that they strongly agreed and 37.8% (n=51) indicating that they somewhat agreed

with the statement, “I am knowledgeable about seagrasses in the Indian River Lagoon.” 10.4% of participants (n=14) neither agreed nor disagreed with this statement, 19.3% (n=26) somewhat disagreed, and 20.0% of participants (n=27) strongly disagreed. 88.3% of participants (n=121) believed that seagrasses in the Indian River Lagoon are important, and 11.7% (n=16) of participants were unsure of the importance of seagrasses in the lagoon. No participants indicated that they did not believe seagrasses in the Indian River Lagoon are important.

Figure 14

Visitor survey participants’ knowledge about seagrasses in the Indian River Lagoon



Note. Survey participants (n=137) were asked to rate on a 5-point Likert scale how much they agreed with the statement “I am knowledgeable about seagrasses in the Indian River Lagoon.”

When compared to their knowledge of seagrasses, a higher percentage of participants who believed that seagrasses in the Indian River Lagoon are important also believed they are

knowledgeable about seagrasses in the Indian River Lagoon than those who were unsure about the importance of seagrasses. 13.4% of participants who believed that seagrasses are important strongly agreed and 42.0% of participants somewhat agreed that they are knowledgeable about seagrasses. In contrast, among those participants who indicated that they were unsure if seagrasses in the Indian River Lagoon are important, 75.0% of participants strongly disagreed and 12.5% of participants somewhat disagreed that they are knowledgeable about seagrasses in the Indian River Lagoon.

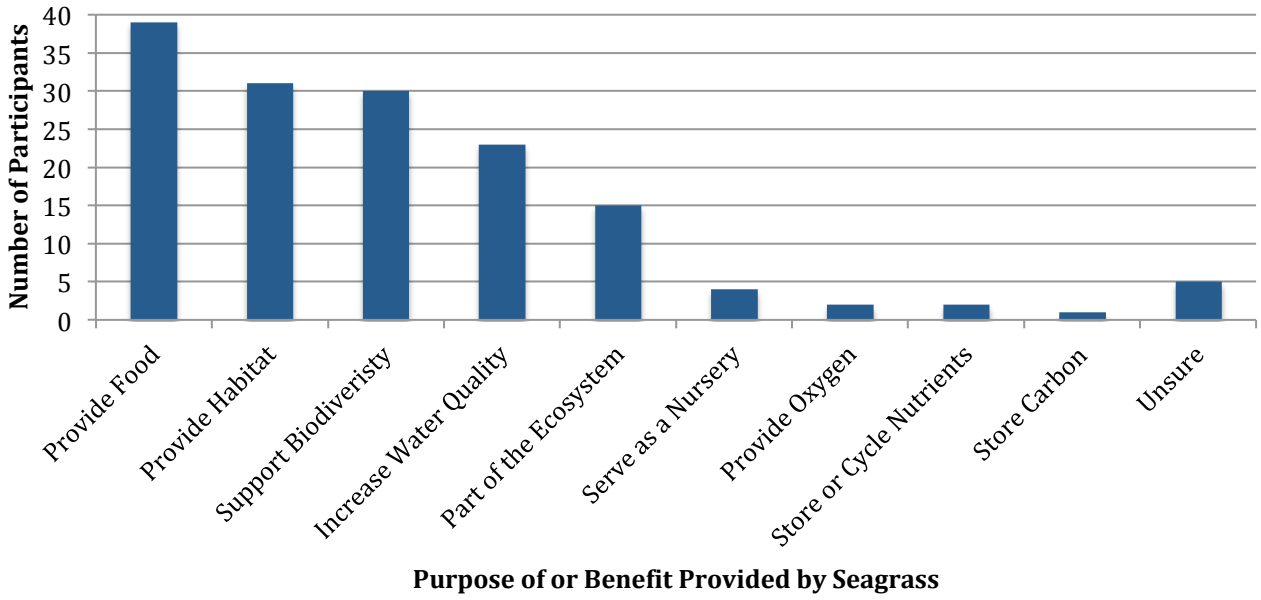
Visitor Survey participants' beliefs about why seagrasses are or are not important.

88 participants responded to the open-ended question asking them why they believed that seagrasses are or are not important or why they were unsure of the importance of seagrasses. Three participants who responded had previously indicated that they were unsure of the importance of seagrasses, and these participants all reiterated this belief in their written response (e.g., "unsure" or "?"). In addition, 2 participants who indicated that they believed seagrasses are important responded that they were not sure why. Among the remaining 83 participants who responded to this open-ended question, the most frequent response was related to the importance of seagrass as a food source (n=39) (e.g., "food," "feed the marine life," "nutrition," and "provide food"), as seen in Figure 15. Many of these participants specifically stated that seagrasses are food for manatees (n=17). Other frequent responses included the idea that seagrasses provide some type of shelter (n=31) (e.g., "provide habitat for sea life," "shelter," and "hiding"), that seagrasses are important for wildlife or biodiversity in general (n=30) (e.g., "animals rely on it for survival," "protects wildlife," and "healthy wildlife"), and that seagrasses contribute to water quality in some way (n=23) (e.g., "filtration" and "help

clean the water"). In addition to manatees, other species that were specifically mentioned as depending on seagrasses in some capacity included fish (n=6), sea turtles (n=2), and invertebrates (n=1).

Figure 15

Why seagrasses in Indian River Lagoon are or are not important according to visitor survey participants



Note. Survey participants (n=88) were asked in an open-ended format why they believed seagrasses in the Indian River Lagoon were or were not important. Survey responses were coded based on thematic categories.

Visitor survey participants' knowledge and beliefs about threats to seagrasses.

When asked to select the four biggest threats to seagrasses from the provided list, threats related to water quality were selected more often than other threats to seagrasses. The most frequently selected threat was “pollution from pesticides,” with 49.6% of participants selecting this response, as shown in Table 1. Other threats that more than 25% of participants identified as being one of the biggest threats to seagrasses included “pollution from herbicides” (42.1%), “excess nitrogen and/or phosphorous polluting the water” (41.4%), and “stormwater runoff” (31.6%). All other threats to seagrass in the provided list were selected by 1 or more participants. In addition, one participant selected the “other” response option and provided an answer of the “big sugar industry,” most likely referring to the large sugar farms in the center of the state. 4.5% of participants selected “none of the above or unsure.”

Table 1

Visitor survey participants’ beliefs about the biggest threats to seagrasses in the Indian River Lagoon

		I am knowledgeable about seagrasses in the Indian River Lagoon		
	Total	Strongly/Somewhat Agree	Neither Agree/ Disagree	Strongly/Somewhat Disagree
Pollution from pesticides	49.6%	52.9%	50.0%	43.4%
Pollution from herbicides	42.1%	38.2%	57.1%	41.5%
Excess nitrogen and/or phosphorous polluting the water	41.4%	54.4%	35.7%	24.5%
Stormwater runoff	31.6%	38.2%	14.3%	26.4%
Presence of "muck" in the lagoon	23.3%	23.5%	35.7%	18.9%
Increased number of people in the area	21.8%	25.0%	21.4%	17.0%
Litter	21.2%	16.2%	14.3%	28.3%
Damage from boat propellers	18.8%	19.1%	21.4%	17.0%
Dredging for boat channels and construction projects	17.3%	14.7%	28.6%	17.0%
Pollution from farming	17.3%	17.6%	14.3%	17.0%
Shoreline erosion	16.5%	14.7%	21.4%	17.0%
Invasive species	15.0%	11.8%	14.3%	18.9%
People trampling seagrass	9.8%	11.8%	7.1%	7.5%
Too much freshwater entering the lagoon from canals	6.0%	5.9%	0.0%	7.5%
None of the above or Unsure	4.5%	1.5%	7.1%	7.5%
Overgrazing from manatees	3.0%	5.9%	0.0%	0.0%
Overgrazing from other animals	1.5%	2.9%	0.0%	0.0%
Other (Please specify)	0.8%	1.5%	0.0%	0.0%

Note. Survey participants (n=137) were asked to select the biggest threats to seagrasses in the

Indian River Lagoon from a provided list, and responses were compared to how knowledgeable participants were about seagrasses in the Indian River Lagoon. Participants were able to select up to 4 responses.

When responses were compared to how knowledgeable participants believed they were about seagrasses, additional trends emerged. The rate at with participants selected "excess nitrogen and/or phosphorous polluting the water," for example, increased as knowledge about seagrass in the Indian River Lagoon increased. Only 24.5% of those who strongly or somewhat disagreed that they are knowledgeable about seagrasses in the Indian River Lagoon selected this response, compared to 54.4% of the those participants who strongly or somewhat agreed that they are knowledgeable. In addition, 25.0% of participants who strongly or somewhat agreed they are knowledgeable about seagrasses selected "increased number of people in the area," and this answer was selected by at a particularly high rate by of participants who strongly agreed that they are knowledgeable about seagrasses in the Indian River Lagoon (52.9%) in particular. In contrast, this response was selected less than 25% of the time among those who neither agreed or disagreed and strongly or somewhat agreed they were knowledgeable about seagrasses. "Litter," however, was selected at a higher rate among those who strongly or somewhat disagreed that they are knowledgeable about seagrasses (28.3%) than by all other participants. Other responses, such as "pollution from pesticides" and "pollution from herbicides," were selected at a comparatively high rate regardless of knowledge level.

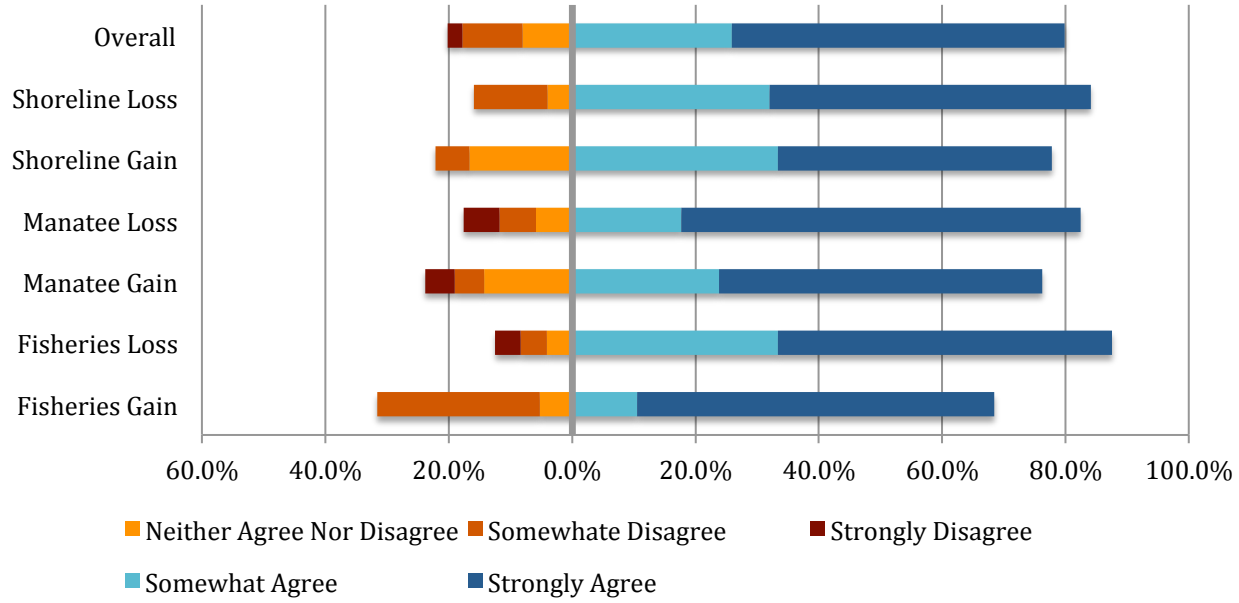
Visitor Survey Participants' responses to messaging frames.

Impact of seagrass loss.

Between 19 and 25 participants were randomly assigned to view each messaging frame, with an average of approximately 21 participants viewing each frame. Overall, 79.8% of participants strongly or somewhat agreed the loss of seagrasses in the Indian River Lagoon directly impacts them after viewing their assigned messaging frame, as shown in Figure 16. When gain and loss frames were compared for each topic (i.e., fisheries, manatees, and shoreline protection), a similar percentage of participants strongly or somewhat agreed the loss of seagrasses impacts them. 79.1% of participants who viewed a fisheries frame, 78.9% of participants who viewed a manatee frames, and 81.4% of participants who viewed a shoreline protection frame strongly or somewhat agreed the loss of seagrass impacts them. When gain frames were collectively compared to loss frames, however, only 74.1% of participants who viewed gain frames strongly or somewhat agreed the loss of seagrasses directly impacts them, while 84.8% of participants strongly or somewhat agreed after viewing a loss frame. This pattern was consistent across individual messaging frames, as all three gain frames had a below average percentage of participants strongly or somewhat agree the loss of seagrasses directly impacts them after viewing the frame. The fisheries gain frame had the lowest percentage of participants respond that they strongly or somewhat agreed that the loss of seagrasses directly impacts them (68.4%), followed by the manatee gain frame (76.2%) and the shoreline protection gain frame (77.8%).

Figure 16

Visitor survey participants' beliefs about the impact of seagrass loss based on messaging frame



Note. Survey participants (n=137) were asked to rate on a 5-point Likert scale how much they agreed with the statement "the loss of seagrasses in the Indian River Lagoon directly impacts me" after viewing 1 of 6 potential messaging frames. Responses of "somewhat agree" and "strongly agree" were considered as having a positive impact.

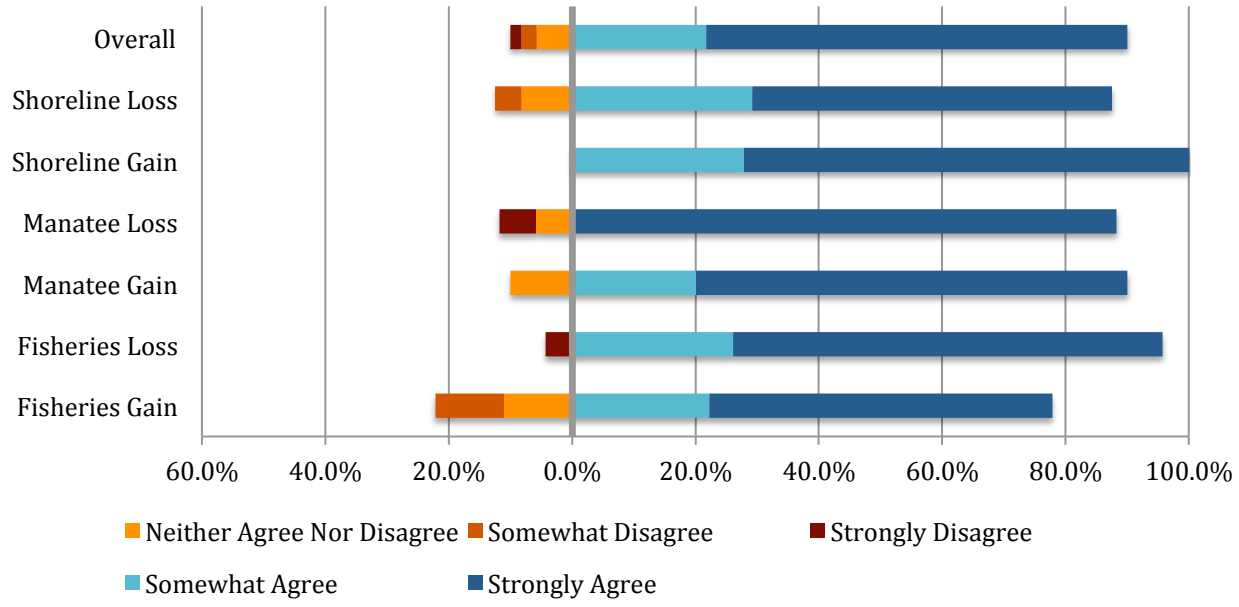
Importance of protecting seagrasses.

90.0% of participants strongly or somewhat agreed that protecting seagrasses in the Indian River Lagoon is important to them after viewing one of the messaging frames, as shown in Figure 17. When compared across topics, only a slightly higher percentage of participants who viewed a shoreline frame strongly or somewhat agreed protecting seagrasses is important to them (92.9%) than those participants who viewed a fisheries frames (87.8%) or a manatee frame (89.82%). When gain and loss frames were collectively compared, there was also little difference between groups. 90.6% of participants strongly or somewhat agreed protecting

seagrasses is important to them after viewing a loss frame, and 89.3% of participants strongly or somewhat agreed protecting seagrasses is important to them after viewing a gain frame. There were, however, also some notable differences when frames were compared on an individual level. Only 77.8% of participants who viewed the fisheries gain frame strongly or somewhat agreed protecting seagrasses is important to them, while 95.7% of those who viewed the fisheries loss frame strongly or somewhat agreed. In addition, all participants who viewed the shoreline protection gain frame strongly or somewhat agreed protecting seagrasses is important to them.

Figure 17

Visitor survey participants' beliefs about the importance of protecting seagrasses based on messaging frame



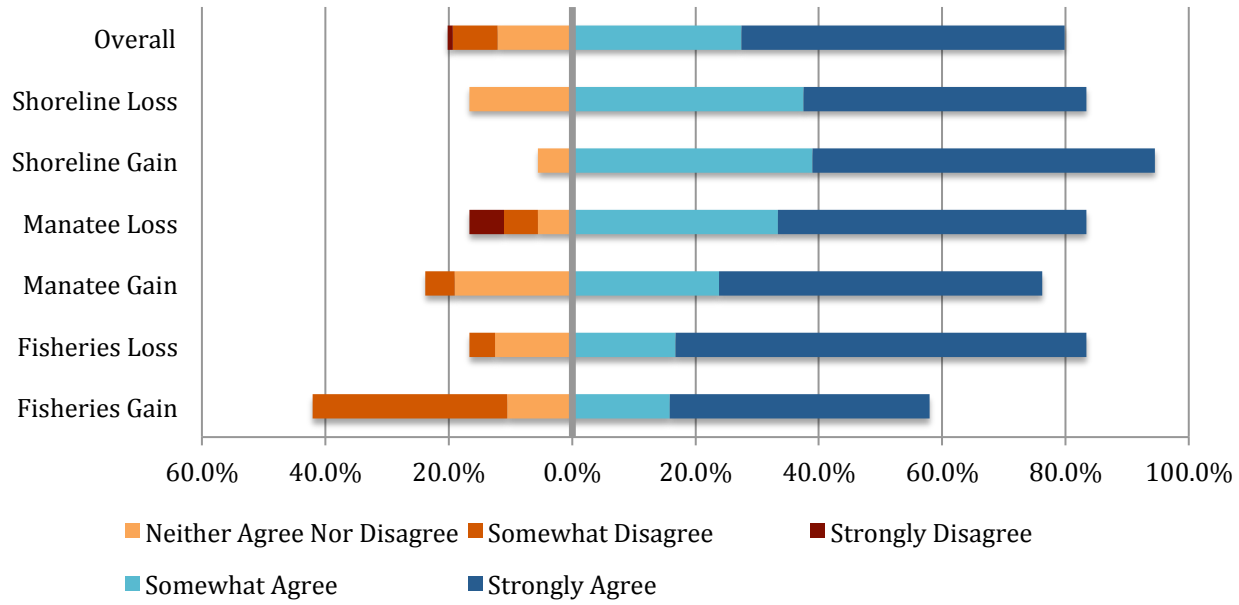
Note. Survey participants (n=137) were asked to rate on a 5-point Likert scale how much they agreed with the statement "protecting seagrasses in the Indian River Lagoon is important to me" after viewing 1 of 6 potential messaging frames. Responses of "somewhat agree" and "strongly agree" were considered as having a positive impact.

Relevance of information.

79.8% of participants strongly or somewhat agreed the information on the sign they viewed was relevant to them, as shown in Figure 18. When compared across topics, a higher percentage of participants who viewed a shoreline protection frame strongly or somewhat agreed the information on the sign was relevant to them (88.1%) compared to those participants who viewed a manatee frame (79.5%) or fisheries frame (72.1%). When gain frames were collectively compared to loss frames, a higher percentage of participants strongly or somewhat agreed the information on the sign was relevant to them after viewing a loss frame (83.3%) than after viewing a gain frame (75.9%). When comparing frames individually, however, there were some discrepancies in this pattern. Both the lowest and highest percentage of visitors agreed the information was relevant to them after viewing one of the gain frames. Only 57.9% of participants who viewed the fisheries gain frame strongly or somewhat agreed the information on the sign was relevant to them. In contrast, 94.5% of participants who viewed the shoreline protection gain frame strongly or somewhat agreed the information was relevant to them.

Figure 18

Visitor survey participants' beliefs about the relevance of information in messaging frame



Note. Survey participants (n=137) were asked to rate on a 5-point Likert scale how much they agreed with the statement "the information on the sign is relevant to me" after viewing 1 of 6 potential messaging frames. Responses of "somewhat agree" and "strongly agree" were considered as having a positive impact.

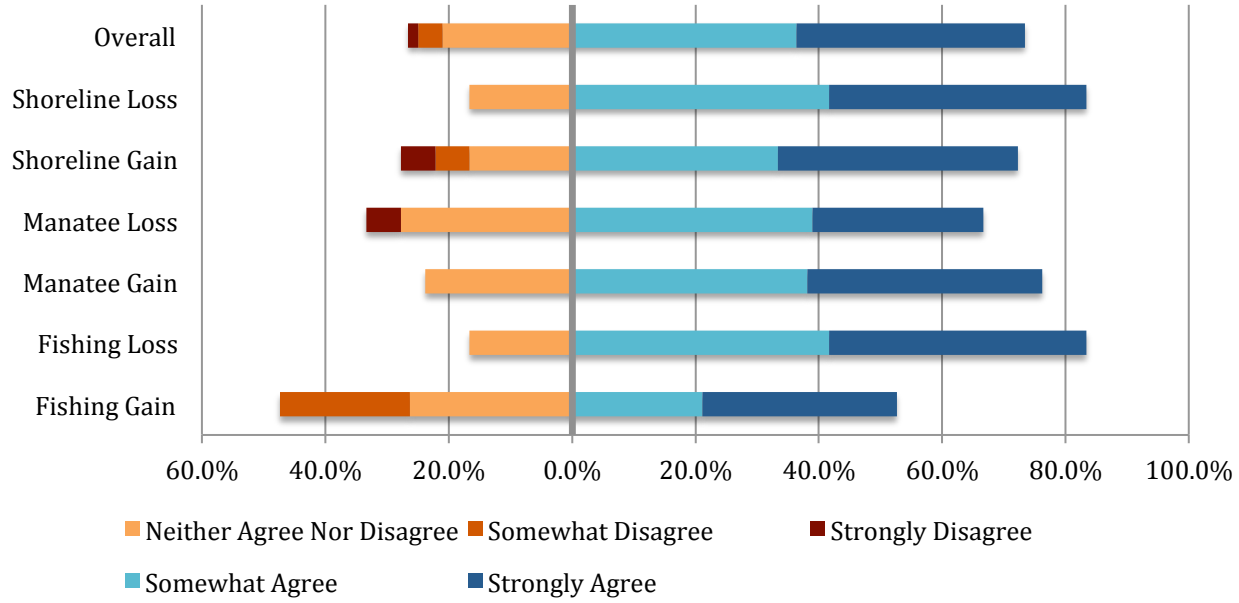
Increased likelihood of taking action.

73.4% of participants strongly or somewhat agreed the information in the frame they viewed made them more likely to take action to protect seagrasses in the Indian River Lagoon, as shown in Figure 19. A higher percentage of participants who viewed a shoreline protection frame agreed the information in the messaging frame made them more likely to take action to protect seagrasses in the Indian River Lagoon than participants who viewed either a fisheries or shoreline protection frame, with 78.6% of visitors strongly or somewhat agreeing they were

more likely to take action after viewing a shoreline protection messaging frame. In comparison, 71.8% of visitors strongly or somewhat agreed the information in the frame made them more likely to take action after viewing a manatee frame, and 69.8% of visitors strongly or somewhat agreed after viewing a fisheries frame. Following the same trend seen with the previous question, a higher percentage of visitors who viewed a loss frame strongly or somewhat agreed the information made them more likely to take action (78.8%) than participants who viewed a gain frame (67.2%). Of all messaging frames, the fisheries gain frame had the lowest percentage of visitors strongly or somewhat agree the information made them more likely to take action to protect seagrasses (52.6%). The highest percentage of participants, however, strongly or somewhat agreed the information on in the messaging frame made them more likely to take action after viewing one of two frames: the fisheries loss frame and the shoreline loss frame. 83.3% of participants who viewed these frames strongly or somewhat agreed the information made them more likely to take action to protect seagrasses.

Figure 19

Visitor survey participants' increased likelihood of taking action to protect seagrasses based on messaging frame



Note. Survey participants (n=137) were asked to rate on a 5-point Likert scale how much they agreed with the statement "the information on the sign makes me more likely to take action to protect seagrasses in the Indian River Lagoon" after viewing 1 of 6 potential messaging frames. Responses of "somewhat agree" and "strongly agree" were considered as having a positive impact.

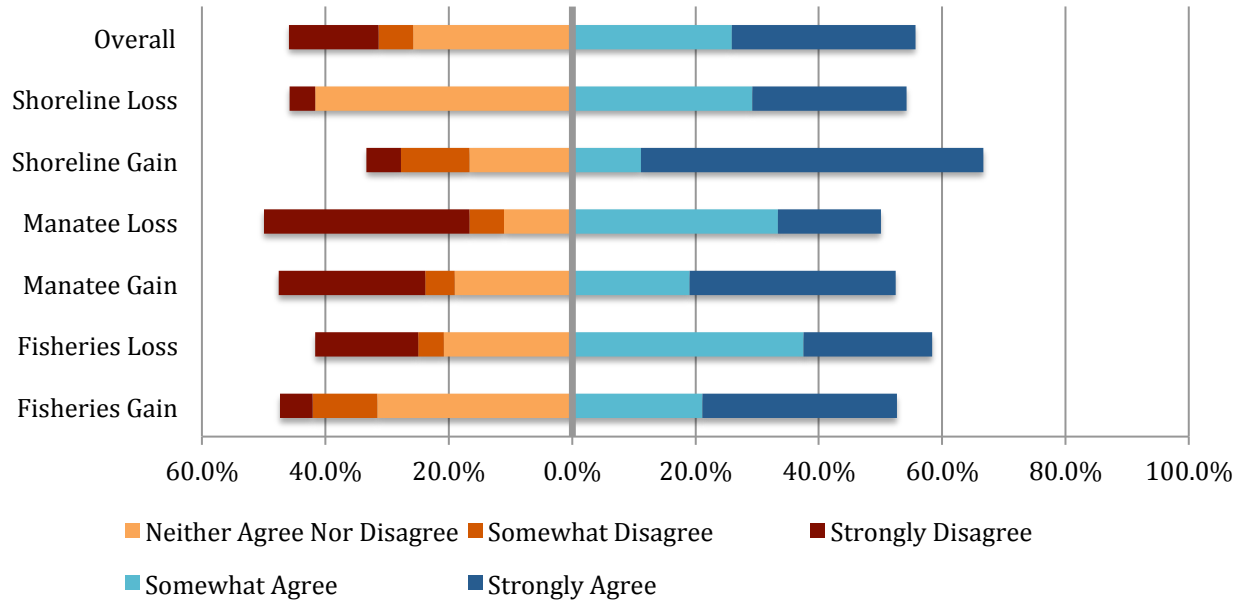
Knowledge gain.

Finally, when asked if they learned something new from viewing the messaging frame, only 55.6% of participants strongly or somewhat agreed that they had, as seen in Figure 20. When compared by topic, the highest percentage of participants indicated they learned something new after viewing a shoreline protection frame, with 59.5% strongly or somewhat agreeing they had learned something new. 55.8% of participants who viewed a fisheries frame strongly or somewhat agreed, and only 51.3% of visitors who viewed a manatee frame strongly

or somewhat agreed they learned something new from the messaging frame. When frames were compared on an individual level, this trend was consistent, with both manatee frames had among the lowest percentages of visitors somewhat agreeing or strongly agreeing they learned something new. When gain frames were collectively compared to loss frames, the percentage of participants who agreed they learned something new was similar, with only a slightly higher percentage of visitors strongly or somewhat agreeing the learned something new after viewing a gain frame (56.9%) than a loss frame (54.5%). This pattern was consistent for both manatee and shoreline protection frames but reversed for fisheries frames. A higher percentage of visitors strongly or somewhat agreed they learned something new after viewing the fisheries loss frame (58.3%) than the fisheries gain frame (52.6%).

Figure 20

Visitor survey participants' knowledge gain about seagrasses based on messaging frame



Note. Survey participants (n=137) were asked to rate on a 5-point Likert scale how much they agreed with the statement "I learned something I did not know about seagrasses in the Indian River Lagoon from reading this sign" after viewing 1 of 6 potential messaging frames. Responses of "somewhat agree" and "strongly agree" were considered as having a positive impact.

Beliefs about ecosystem services of seagrasses.

When asked to select the most important benefits of seagrasses from the provided list, the most frequently selected benefit was "habitat for many different lagoon species," as seen in Table 2. 44.4% of participants selected this response. Other benefits that were selected by more than 25% of visitors included "food for manatees" (39.3%), "improvement of water quality" (36.3%), and "nursery area for juvenile animals in the lagoon" (25.2%). "Support of commercial and/or recreational fishing" was the least frequently selected response and was selected by only 6.7% of participants. In addition, 3.0% of visitors selected "unsure or none of the above," and 1 participant specified "other," providing an answer of "all of the above."

Table 2

Visitor survey participants' beliefs about importance of benefits or ecosystem services provided by seagrasses

	I am knowledgeable about seagrasses in the Indian River Lagoon			
	Total	Strongly/Somewhat Agree	Neither Agree/Disagree	Strongly/Somewhat Disagree
Habitat for many different lagoon species	44.4%	55.9%	50.0%	28.3%
Food for manatees	39.3%	27.9%	21.4%	47.2%
Improvement of water quality	36.3%	41.2%	21.4%	34.0%
Nursery area for juvenile animals in the lagoon	25.2%	29.4%	14.3%	22.6%
Food for sea turtles	21.5%	25.0%	21.4%	17.0%
Oxygen production	17.8%	19.1%	28.6%	13.2%
Prevention of shoreline erosion	15.6%	10.3%	0.0%	26.4%
Protection from storms	10.4%	8.8%	7.1%	13.2%
Nutrient cycling	10.4%	16.2%	0.0%	5.7%
Carbon storage	8.1%	11.8%	14.3%	1.9%
Support of commercial and/or recreational fishing	6.7%	8.8%	7.1%	3.8%
None of the above or unsure	3.0%	1.5%	0.0%	5.7%
Other (Please specify)	0.7%	0.0%	0.0%	0.0%

Note. Survey participants (n=137) were asked to select the most important benefits provided by seagrasses in the Indian River Lagoon from a provided list, and responses were compared to how knowledgeable participants were about seagrasses in the Indian River Lagoon. Participants were able to select up to 3 responses.

When selected benefits were compared to participants' knowledge of seagrasses, there were, again, some notable differences. "Prevention of shoreline erosion," for example, was selected a much higher rate among those participants who strongly or somewhat disagreed they are knowledgeable about seagrasses in the Indian River Lagoon (26.4%) than those who neither agreed or disagreed (0.0%) or strongly or somewhat agreed (10.3%). In contrast, among these groups, "habitat for many different lagoon species" was consistently selected by 50% or more of participants. This response was selected by only 28.3% of participants who strongly or somewhat disagreed they are knowledgeable about seagrasses in the Indian River Lagoon.

Conservation actions visitors are most willing to take to protect seagrasses.

Finally, when asked to select the actions they are most willing to do to protect seagrasses in the Indian River Lagoon from the provided list, there was no clear consensus

among participants. All possible responses except two were selected by more than 25% of participants, as shown in Table 3. For these actions, all selection rates fell within a range of 28.9% to 38.5%. The two options that fell below a 25% selection rate were “wash my car at a carwash rather than at home” (22.2%) and “convert my septic to sewer” (7.4%). In addition, 1.5% of participants selected “none of the above or unsure.” No visitors selected the “other” option.

Table 3

Conservation actions visitor survey participants are most willing to take to protect seagrasses

	I am knowledgeable about seagrasses in the Indian River Lagoon			
	Total	Strongly/Somewhat Agree	Neither Agree/Disagree	Strongly/Somewhat Disagree
Plant native plants in my yard	38.5%	42.6%	42.9%	32.1%
Keep litter out of storm drains	37.8%	39.7%	28.6%	37.7%
Reduce or eliminate my use of pesticide	37.0%	36.8%	42.9%	35.8%
Reduce or eliminate my use of fertilizer	32.6%	42.6%	42.9%	17.0%
Pick up my pet's waste	31.9%	35.3%	21.4%	30.2%
Keep my grass clippings and other yard waste out of stor	28.9%	32.4%	21.4%	26.4%
Wash my car at a car wash rather than at home	22.2%	20.6%	14.3%	26.4%
Convert my septic system to a sewer connection	7.4%	10.3%	0.0%	5.7%
None of the above or unsure	1.5%	1.5%	0.0%	1.9%
Other (Please specify)	0.0%	0.0%	0.0%	0.0%

Note. Survey participants (n=137) were asked to select the conservation actions they were most willing to take to protect seagrasses in the Indian River Lagoon from a provided list, and responses were compared to how knowledgeable participants were about seagrasses in the Indian River Lagoon. Participants were able to select up to 3 responses.

However, as with previous questions, when selected conservation actions were compared to participants’ knowledge of seagrasses, some notable trends emerged. While “plant native plants in my yard” was selected at a high rate across all participants, it was

generally selected at a higher rate among those participants who strongly or somewhat agreed they are knowledgeable about seagrasses (42.6%) and who neither agreed nor disagreed (42.9%) than among those participants who strongly or somewhat disagreed (32.1%). The same trend was seen with the percentage of participants who selected "reduce or eliminate my use of fertilizer." Only 17.0% of participants who strongly or somewhat disagreed they are knowledgeable about seagrasses in the Indian River Lagoon selected this response compared to 42.6% of participants who strongly or somewhat agreed they are knowledgeable about seagrasses in the Indian River Lagoon and 42.9% of those who neither agreed nor disagreed.

Discussion

Summary of key findings

1. What messaging strategies are currently in use at visitor centers?

Seagrasses are a ubiquitous topic in visitor centers with interpretive elements about the Indian River Lagoon across the region. While 1 of the 11 facilities included in the content analysis provided little information beyond indicating the presence of seagrasses in the lagoon, the overwhelming majority of facilities provided information about numerous ecosystem services provided by seagrasses, the loss of seagrasses in the lagoon, and conservation actions that can be taken to protect and restore seagrasses. Among these topics, there was a slightly stronger emphasis on the ecosystem services provided seagrasses, with facilities providing the most information about this aspect of messaging.

Visitor centers frequently took a wide-lens approach to messaging, providing a breadth of information about an array of seagrass and seagrass conservation topics, rather than focusing on more in-depth explanations or contextualization. In addition, most messaging was

straightforward and succinct, outlining or listing the benefits of seagrasses and the causes of loss, followed by possible conservation actions. Many interpretive elements did not appear to have a primary focus on provoking thought or helping the audience form personal connections to the information presented, instead providing a factual overview of the topic.

2. What do visitors already know and believe about seagrasses and seagrass conservation in the Indian River Lagoon?

The survey of visitors at Brevard Zoo provided valuable insight into what guests to visitor centers in the region, such as Brevard Zoo, know and believe about seagrasses. Approximately half of survey participants agreed that they are knowledgeable about seagrasses in the Indian River Lagoon, and the majority of participants agreed that seagrasses are a valuable part of the lagoon ecosystem. Interestingly, no participants, regardless of knowledge level, indicated that they did not believe seagrasses are important, although a small percentage of participants were unsure of their importance.

Participants frequently tied seagrasses to concerns about water quality and indicated their understanding that seagrasses both impact water quality and are impacted by water quality. Participants often mentioned the role of seagrasses in supporting water quality when asked why seagrasses are important. When asked to select the biggest threats to seagrasses, the most frequently selected responses all related to water quality, although, surprisingly, participants more frequently selected pollution from pesticides and herbicides than pollution from excess nitrogen and/or phosphorous when asked to select the biggest threats to seagrasses in the lagoon. In addition, participants indicated that they are also knowledgeable of and value the role of seagrasses in supporting biodiversity, and when asked why seagrasses are important,

seagrasses were frequently recognized for the provision of food, with manatees as the most frequently mentioned species dependent on seagrasses as a food source.

3. In what ways to visitors' knowledge and beliefs about seagrasses align or not align with current messaging strategies?

The role of seagrasses in supporting commercial and/or recreational fisheries was prominent in messaging across the region. However, participants in the visitor survey did not indicate that the role of seagrasses in supporting fisheries is of primary value or concern. Several topics, including the role of seagrasses in supporting general biodiversity and improving water quality, were more highly valued by participants. While the role of seagrasses in supporting biodiversity is prominent in current messaging, the role of seagrasses in improving water quality is less frequently mentioned in current messaging strategies than several other topics, including the importance of seagrasses for fisheries.

In addition, a number of key findings from the visitor survey indicated the need for more in-depth contextualization and explanation to address lack of knowledge about particular aspects of seagrass and seagrass conservation and potential misunderstandings about these topics. Most notably, there was a general lack of consensus among participants regarding which conservation actions they are most willing to take to protect seagrasses, along with multiple discrepancies in beliefs about seagrasses among those of varying degrees of knowledge about seagrasses.

4. Key findings from the pilot study of messaging frames

After viewing one of the messaging frames in the pilot test, participants generally agreed the loss of seagrasses would directly impact them, protecting seagrasses is important to them,

the information in the frame viewed is relevant to them, and the information made them more likely to take action to protect seagrasses after viewing their assigned frame. However, nearly 45% of participants indicted they did not learn something new from reading the presented frame.

When gain frames were collectively compared to loss frames, loss frames tended to be more impactful, as has been found in prior studies of the impact of gain and loss frames in environmental messaging (Cheng et al., 2011; Ropret Homar & Knežević Cvelbar, 2021). A higher percentage of participants agreed the loss of seagrasses directly impacts them, the information in the frame they viewed is relevant to them, and the information in the frame makes them more likely to take action to protect seagrasses after viewing a loss frame than a gain frame. However, there were several notable discrepancies from this pattern when frames were examined on an individual level.

When compared collectively by topic, shoreline protection frames tended to be more impactful than manatee or fisheries frames. Participants who viewed a shoreline frame were more likely to agree the information in the frame is relevant to them, the information made them more likely to take action to protect seagrasses, and they learned something they did not know from the frame than those who viewed manatee or fisheries frames. Surprisingly, manatee frames were not consistently among the most impactful, despite participants' general knowledge regarding the importance of seagrasses for manatees.

Recommendations to improve impact of messaging

While it is encouraging current messaging strategies provide visitors with a range of valuable information about seagrasses, the content analysis and results from the survey of

visitors revealed several trends in messaging that might unintentionally reduce messaging impact and buy-in for conservation action. Messaging may, therefore, be improved by the implementation of the following recommendations:

Recommendation 1: Increase focus on depth of understanding through context and explanation.

Most facilities' messaging strategies relied on presenting information through a broad-lens that addressed a wide-range of topics briefly, rather than focusing on in-depth contextualization or explanation. While this strategy may be advantageous in exposing visitors to a breath of information, it may also fail to provide adequate information for visitors to fully understand the scope of the issue or which actions can be taken to effectively protect and restore seagrasses across the lagoon. Research on behavior change has shown that explanation can be a powerful part of helping audiences link causes to appropriate solutions, which in turn increases buy-in for proposed actions (Kendall-Taylor, 2017; Van Leuvan et al., 2022). Some causes of seagrass loss, such as damage from boating practices, have an easily understood relationship between the cause of loss and related solution. However, many threats to seagrasses in the lagoon, such as water pollution, require a more in-depth understanding of the mechanism behind the cause of loss to understand which conservation actions are most likely to positively impact seagrass conservation. Water pollution was frequently included in current messaging. However, definitions of "pollution" varied greatly, and there was often inadequate explanation for visitors to fully understand how water pollution impacts seagrasses. By failing to provide adequate explanation and context, current messaging may be failing to gain buy-in for appropriate conservation action.

Data from the Phase 2 survey of visitors further supported the need for messaging strategies that focus on explanation. Survey data reflected a lack of consensus among participants regarding which conservation actions they were most willing to take. Actions that would not directly address the primary drivers of seagrasses loss in the lagoon (e.g., “keeping litter out of storm drains”) were selected at similar rate to those actions that more directly address water quality and, therefore, seagrass loss (e.g., “plant native plants in my yard”). Further, those participants who indicated they are knowledgeable about seagrasses in the Indian River Lagoon selected threats that more directly impact nutrient pollution (e.g., “excess nitrogen and/or phosphorous polluting the water”) and solutions that would directly address this concern (e.g., “plant native plans in my yard” or “reduce or eliminate my use of fertilizer”) at a higher rate than those participants who indicated they are less are knowledgeable about seagrasses. These findings may be indicative of an underlying lack of understanding of the mechanism behind seagrass loss, which, in turn, results in difficulties in selecting appropriate conservation actions, especially among those visitors who are less knowledgeable about seagrasses in the Indian River Lagoon.

In addition, after viewing one of the messaging frames, an overall higher percentage of participants indicated they believe seagrasses are important than believe the loss of seagrasses may directly impact them. This discrepancy may be attributable to a lack of understanding of the importance of seagrasses, leading to misconceptions about the potential impacts of seagrass loss for the community. These misconceptions could also be addressed by messaging strategies with more in-depth explanation. For example, while seagrasses make up a large proportion of manatees’ diets in the Indian River Lagoon (Allen et al., 2022), seagrasses were

often portrayed as one of many potential food sources for manatees in current messaging. Comparisons about the relative importance of seagrasses in manatees' diets may help address misconceptions about their ability to rely on other food sources and help visitors more fully understand the impact the loss of seagrasses may have on manatee populations. Similarly, messaging strategies that quantify how fisheries impact the local economy (East Central Florida Regional Planning Council & Treasure Coast Regional Planning Council, 2016; Florida Fish and Wildlife Conservation Commission, 2022) or the cultural and historical importance of commercial and recreational fisheries (Osborn, 2016) may increase the impact of messaging about fisheries, even among visitors who do not fish or rely on commercial fisheries for household income.

Recommendation 2: Create a regional messaging framework to ensure a consistent, cohesive approach to priority messaging topics.

In addition to further contextualization and explanation, a greater focus should be placed on messaging consistency. During the content analysis, there were multiple occasions in which information about seagrass loss in the lagoon was inconsistent or even contradictory both within and between facilities. For example, information regarding both the causes and scope of seagrass loss varied between visitor centers, and in some instances, proposed conservation actions did not align with the provided causes of seagrass loss. These inconsistencies may lead to misconceptions that negatively impact messaging impact and reduce buy-in for conservation actions. For example, visitors who visit multiple facilities providing differing data about the extent of seagrass loss may believe that lagoon managers do not agree on the conservations status of seagrasses. Mismatches between causes of seagrass loss and proposed conservation

actions may lead to a belief that there is inadequate information to understand which actions may be most appropriate to protect seagrasses. A focus on developing consistent, cohesive messaging may address any potential misconceptions.

Further, when planning interpretive elements, it is important to remember that learning is incremental (Falk, 2005). Consistent and repeated exposure to the same information multiple times in various formats has a positive impact on knowledge gain. Visitor centers along the Indian River Lagoon can support knowledge gain about seagrasses and related conservation actions through multiple interpretive experiences at one facility or experiences at several facilities over time. It may, therefore, be valuable to not only directly address instances of conflicting or inconsistent information but also to build consensus between facilities in determining what information about seagrasses should be included in messaging and construct an agreed-upon framework for addressing those topics.

Efforts to build this regional messaging framework should be done in close collaboration with Indian River Lagoon managing bodies and research institutions. A cooperative approach to messaging design will help to ensure that messaging is aligned with the most significant and up-to-date information regarding seagrass conservation and management. Due to the current wide-lens messaging strategy used in many facilities, topics that are not of primary concern to current seagrass management, such as irresponsible boating practices, are frequently included in messaging. While this approach may be intended to provide visitors with a broad knowledge base about seagrasses, it may unintentionally reduce learning about key messaging takeaways as visitors can only attended to a limited amount of information at any one time (Ham, 1992). A more strategic, cohesive regional messaging focus on topics such as the impact of reducing

nutrient pollution, removal of muck, or replanting of seagrasses that are more directly aligned with current management priorities (Indian River Lagoon National Estuary Program, 2019) may, therefore, help be instrumental in building visitor knowledge and increasing overall messaging impact.

Further, a concise, unified messaging approach may help visitors prioritize knowledge related to threats to seagrass loss. On the visitor survey, when asked to identify the biggest threats to seagrasses, the most frequently selected options all related to water quality, but "pollution from herbicides" and "pollution from pesticides" were selected at a higher rate than "excess nitrogen and phosphorous polluting the water." While herbicides and pesticides may contribute to declining water quality in the Indian River Lagoon, they are, again, not the principle focus of current efforts to protect and restore seagrasses (Indian River Lagoon National Estuary Program, 2019). A more focused approach to messaging across the region (combined with adequate explanation that helps visitors understand why issues such as nutrient pollution are of primary concern to seagrass management) may be beneficial in helping visitors more consistently identify priority threats to seagrasses, understand why these threats are of particular concern, and then select conservation actions that most directly address these concerns.

Recommendation 3: Reconsider the focus on the importance of seagrasses in supporting commercial and/or recreational fisheries.

When compared collectively by topic, fisheries frames were consistently among the least impactful messaging frames, and on an individual level, the fisheries gain frame was the least impactful of all tested messaging frames. After viewing the fisheries gain frame, participants

were least likely to agree that the loss of seagrasses impacts them, protecting seagrasses is important to them, the information in the frame is relevant to them, or they are more likely to take conservation action to protect seagrasses. In addition, as with other frames, a low percentage of participants indicated that they learned something they did not know from this frame, indicating that even though participants are aware that seagrasses support fisheries, this information may not be as relevant or impactful as other messaging approaches.

While the overall response to the fisheries gain frame may be in part attributable to a lack of understanding of the importance of fisheries within the region, this messaging approach may also simply fail to align with what people most value about seagrasses in the Indian River Lagoon. When participants in the visitor survey were asked why they believed seagrasses were important, 6 of 88 participants mentioned fish or fisheries in their response. Only 6.7% of participants selected “support of commercial and/or recreational fisheries” among the options provided when asked to select the most important benefits provided by seagrasses, with a low number of individuals selecting this response regardless of level of knowledge about seagrasses in the Indian River Lagoon.

This finding is especially important in consideration of the widespread focus on the importance of seagrasses in supporting commercial and/or recreational fisheries in current messaging strategies. Messaging about the importance of seagrass for fisheries was present in 9 of the 11 visitor centers included in the content analysis. Misalignment between what the audience most values about seagrasses and the information included in current messaging may detract from the overall impact of messaging, thus indicating a potential need to refocus messaging on other ecosystem services provided by seagrasses in the lagoon.

Recommendation 4: Consider increased use of shoreline protection framing.

While survey findings did not support the continued use of fisheries frames, the survey did reveal a lesser-used messaging strategy that may help increase impact of messaging in the region. Shoreline protection frames were among the most impactful of the tested messaging frames. When compared collectively, these frames had the highest percentage of participants who agreed the information was relevant to them, the information presented made them more likely to take action to protect seagrasses in the Indian River Lagoon, and they learned something they did not know from the frame. On an individual level, the shoreline loss frame had among the highest percentage of participants agree that the information presented made them more likely to take action to protect seagrasses, while the shoreline gain frame had the highest percentage of participants who agreed that, based on the information in the frame, seagrasses protecting seagrasses is important to them and the information is relevant to them. This messaging frame also had the highest percentage of participants agree that they learned something they did not know about seagrasses from reading the information in messaging frame. When asked to select the benefits of seagrass that were most important to them on the visitor survey, shoreline protection was not among the most frequently selected responses across all participants. This response, however, was selected at a higher rate among those participants who were less knowledgeable about seagrasses in the Indian River Lagoon. These findings indicate that messaging that emphasizes the importance of seagrasses in shoreline protection may be valuable in increasing knowledge and gaining buy-in among all visitors, as well as among those visitors who are also less familiar with seagrass ecology and conservation in particular.

As mentioned previously, when gain frames were collectively compared to loss frames, loss frames tended to be more impactful. The shoreline frames, however, did not follow this trend. While the shoreline loss frame was particularly valuable in increasing likelihood of taking conservation action, the shoreline gain frame tended to be more impactful overall. Further testing of shoreline protection messaging is recommended to help to refine this messaging frame and determine the most impactful way to further incorporate shoreline protection into future messaging. Currently only 6 of the 11 centers included in the content analysis provided information about the role of seagrasses in shoreline stabilization and/or prevention of erosion, and 3 facilities included information about the role of seagrasses in protection from storms.

Recommendation 5: Test additional frames aligned with participant beliefs and values.

In addition to the messaging frames tested in the visitor survey, results from the visitor survey revealed several other topics that may also improve the impact of seagrass messaging strategies and, therefore, warrant additional testing. Notably, participants indicated that the role of seagrasses in supporting overall biodiversity and improving water quality are particularly important to them. These ecosystem services were among the most frequent responses both when asked to select the most important benefits of seagrasses from the provided list and when asked why seagrasses are important in an open-ended format. While the importance of seagrasses for supporting biodiversity was prevalent in current messaging strategies with 10 of the 11 visitor centers in the content analysis including messaging related to this topic in some capacity (e.g., the role of seagrasses as food/habitat and as a nursery), the role of seagrasses in improving water quality was less frequently used in current messaging. Only 6 of the 11 visitor

centers addressed the role of seagrasses in improving water quality, indicating the potential value of further testing and use of this messaging frame.

Further, it may be beneficial to conduct additional testing regarding the impact of manatee messaging frames. When asked why seagrasses are important, the importance of seagrasses as a food source was frequently connected to its specific importance for manatees. This finding may be related to visitors' general familiarly with manatees' dependence of seagrass, as the highest percentage of visitors indicated that they did not learn something new after viewing a manatee frame. However, this finding may also reflect the importance that visitors place on the continued presence of a healthy population of these charismatic animals in the lagoon. In fact, due to their charismatic nature, manatees may be able to serve as "flagship species," or a species that serves as a marketing tool to raise awareness for a conservation marketing campaign (Verissimo et al., 2011), for seagrass conservation efforts in the Indian River Lagoon. Thus, messaging highlighting the importance of seagrasses for manatees may be a valuable framing approach, but further evaluation is needed to refine this particular messaging strategy to maximize impact.

Recommendation 6: Conduct additional evaluation focused on recommendations for conservation action.

Additional evaluation is also critical to better understanding buy-in for seagrass specific conservation action. Over a quarter of participants indicated that messaging frame they viewed did not increase their likelihood of taking action to protect seagrasses in the lagoon, and there was little consensus among participants on which conservation actions they would be most likely to take to protect seagrasses in the lagoon. However, the tested messaging frames

provided little explanation or context and may not have provided enough information for participates to select appropriate conservation actions. As mentioned previously, without fully understanding threats to seagrasses, impacts of seagrass loss, or the relationship between proposed solutions and the ecological processes contributing to seagrass loss, it may be difficult for people to assess which actions they are most willing to take or how appropriate or impactful a particular action may be.

Research on behavior change shows that the ease of or lack of barriers in engaging in a particular action may influence people's likelihood of engaging in conservation behaviors (Schultz, 2014; Van Leuvan et al., 2022). For some conservation actions (such as "converting from septic to sewer" which was selected at a low rate among participants), cost and accessibility may be significant barriers. In contrast, it may be much easier for people to reduce or eliminate their use of herbicides or pesticides, the two of the more frequently selected responses. These actions may be particularly easy if people do not frequently use these products or believe that herbicide and pesticide use are among the primary drivers of seagrass loss, as was indicated on the visitor survey. Understanding the cost of and barriers to adoption of a conservation action may, therefore, be key in determining which actions to include in messaging and how to most effectively approach messaging about those actions, thus warranting additional evaluation.

Further evaluation should also include testing of collective or community-level solutions. While current messaging strategies focus more heavily on individual-level actions and the visitor survey only included individual-level actions, collective or community-level actions, such as support for legislation or government funding for restoration projects, may also play an

important part in the successful seagrass conservation and management of seagrasses in the Indian River Lagoon. As with individual-level solutions, understanding the cost of or barriers to participation in or support of community-level solutions could help determine the most effective messaging strategies for increasing buy-in to these conservation actions.

Recommendation 7: Continue evaluation efforts at multiple facilities and throughout the development of new interpretive elements.

The Indian River Lagoon and its watershed cover a large portion of the eastern portion of Florida (Indian River Lagoon National Estuary Program, 2019), and additional evaluation efforts are undoubtedly needed to develop effective interpretive elements across the region. While this evaluation provided valuable initial information about participants' beliefs and values regarding seagrasses in the Indian River Lagoon, additional, on-going evaluation should be done in collaboration with other visitor centers located in different geographic areas along the length of the lagoon. A cohesive regional messaging framework may help address current messaging inconsistencies, but it is important to understand how messaging may need to be tailored to meet the specific needs of various regions and facilities within the area.

Looking ahead, it is also imperative that evaluation efforts are integrated into the development, creation, and implementation of future interpretive elements about seagrasses. While front-end evaluation can help to inform initial design ideas, on-going evaluation efforts should be used to refine the design of interpretive elements and ensure messaging goals are met following creation and installation (Hayward, 2013).

Conclusion

Seagrasses are a vital part of the Indian River Lagoon ecosystem, and the loss of these aquatic plants has the potential to have a profound and far-reaching impact on the lagoon and surrounding communities. A multitude of efforts are already underway to help protect and preserve this vital resource (Indian River Lagoon National Estuary Program, 2019; Tetra Tech, Inc., 2022). Visitor centers throughout the region can play a key role in helping build stakeholder buy-in to protect and sustainably manage seagrasses throughout the length of the lagoon (Ballantyne & Packer, 2005; Pearson et al., 2014; Swim et al., 2017). Through numerous interpretive elements, these facilities are already providing opportunities for guests to learn about the importance of seagrasses, threats to seagrasses in the Indian River Lagoon, and how they can take action to help protect this important natural resource. However, current messaging strategies utilized in these facilities may also be unintentionally limiting impact of messaging efforts.

Findings from this front-end evaluation study revealed several ways that messaging within the region might be improved to increase messaging impact, building visitor knowledge about priority seagrass management concerns and buy-in for effective conservation actions. A focus on providing adequate explanation and contextualization in messaging can help visitors better understand the causes of seagrass loss, the impact loss of seagrasses will have on the community as a whole, and which conservation actions may be most beneficial. The creation of a cohesive, regional messaging framework can address messaging inconsistencies and help to increase learning about priority information across multiple experiences in or visits to regional facilities. In addition, a re-evaluation of messaging strategies can help to ensure that messaging is aligned with what visitors most value about seagrasses, and additional evaluation efforts can

be taken to understand potential barriers and costs to buy-in for conservation action. By incorporating the information found through this front-end evaluation, and conducting on-going evaluation efforts as new interpretive elements are developed, the network of visitor centers in the region can increase their impact in building needed buy-in for successful conservation efforts, helping to protect seagrasses and create a more sustainable future for the communities surrounding the Indian River Lagoon.

Acknowledgements

I would like to express my deepest gratitude to Brevard Zoo for allowing me to access to their facility to conduct the visitor survey over many weeks. I am extremely grateful to my co-workers at Brevard Zoo and the volunteers who graciously assisted, acted as a sounding board, and provided on-going feedback on this capstone project. I am also grateful for the support and guidance of my capstone advisor, Dr. Samuel Chan, as well as to my committee members, Dr. Michelle Barnhart and Dave Stemper. Their support, flexibility, and input were invaluable in helping me navigate my capstone project. Lastly, I'd like to mention my husband and parents who supported me throughout this journey and allowed me to take this next step in my professional career.

References

Adelman, L.M., Falk, J.H., & James, S. (2020). Impact of Nation Aquarium in Baltimore on visitors' conservation attitudes, behavior, and knowledge. *Curator, 43*(1), 33-61. https://doi.org/10.111/j.2151-6952.2000.tb01158.x

Allen, A. C., Beck, C. A., Sattelberger, D. C., & Kiszka, J. J. (2022). Evidence of a dietary shift by the Florida manatee (Trichechus manatus latirostris) in the Indian River Lagoon inferred from stomach content analyses. *Estuarine, Coastal and Shelf Science*, *268*, 107788. https://doi.org/10.1016/j.ecss.2022.107788

Ballantyne, R. & Packer, J. (2005). Promoting environmentally sustainable attitudes and behaviors through free-choice learning experiences: What is the state of the game? *Environmental Education Research, 11*(3), 281-295. https://doi.org/10.1080/13504620500081145

Bolderdijk, J. W., Gorsira, M., Keizer, K., & Steg, L. (2013). Values determine the (in)effectiveness of informational interventions in promoting pro-environmental behavior. *PLoS ONE*, *8*(12), e83911. https://doi.org/10.1371/journal.pone.0083911

Brochu, L., & Merriman, T. (2015). *Personal interpretation: Connecting your audience to heritage resources* (3rd edition). InterPress.

Cheng, T., Woon, D. K., & Lynes, J. K. (2011). The Use of Message Framing in the Promotion of Environmentally Sustainable Behaviors. *Social Marketing Quarterly*, *17*(2), 48–62. https://doi.org/10.1080/15245004.2011.570859

Chong, D. & Druckman, J. N. (2007). Framing theory. *Annual Review of Political Science*, *10*(1), 103–126. https://doi.org/10.1146/annurev.polisci.10.072805.103054

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van den Belt, M. (1998). The value of the world's ecosystem services and natural capital. *Ecological Economics*, *25*(1), 3–15. https://doi.org/10.1016/S0921-8009(98)00020-2

Cullen-Unsworth, L. C., Nordlund, L. M., Paddock, J., Baker, S., McKenzie, L. J., & Unsworth, R. K. F. (2014). Seagrass meadows globally as a coupled social–ecological system: Implications for human wellbeing. *Marine Pollution Bulletin*, *83*(2), 387–397. https://doi.org/10.1016/j.marpolbul.2013.06.001

Dai, S., Chen, K., & Jin, R. (2022). The effect of message framing and language intensity on green consumption behavior willingness. *Environment, Development and Sustainability*, *24*(2), 2432–2452. https://doi.org/10.1007/s10668-021-01540-8

Dawes, C.J., Hanisak, D., & Kenworthy, W.J. (1995). Seagrass biodiversity in the Indian River Lagoon. *Bulletin of Marine Science, 57*(1), 59-66.

Dine, H. (2010). *A seagrass meadow. Florida Keys National Marine Sanctuary* [Photograph]. Flickr. https://www.flickr.com/photos/noaaphotolib/5077876455

Duarte, C. M., Dennison, W. C., Orth, R. J. W., & Carruthers, T. J. B. (2008). The charisma of coastal ecosystems: Addressing the imbalance. *Estuaries and Coasts*, *31*(2), 233–238. https://doi.org/10.1007/s12237-008-9038-7

East Central Florida Regional Planning Council & Treasure Coast Regional Planning Council. (2016). *Indian River Lagoon economic valuation update. https://loveourlagoon.com/IRL-Economic-Valuation-Update-07252016.pdf*

Falk, J.H. (2005). Free-choice environmental learning: Framing the discussion. *Environmental*

Education Research, 11(3), 265-280. https://doi.org/10.1080/13504620500081129

Falk, J.H., & Dierking, L.D. (2000). *Learning from museums: Visitor experiences and the making of meaning.* AltaMira.

Florida Department of Environmental Protection. (2019). *Water management districts.* https://floridadep.gov/water-policy/water-policy/content/water-management-districts

Florida Fish and Wildlife Conservation Commission. (2022). *Economic impacts of saltwater fishing in Florida.* https://myfwc.com/conservation/value/saltwater-fishing/

Gilmore, R.G., Donohoe, C.J., & Cooke, D.W. (1981). *Fishes of the Indian River Lagoon and Adjacent Waters, Florida.* Harbor Branch Foundation. http://fau.digital.flvc.org/islandora/object/fau%3A6425

Google. (2023a). [Google map of Indian River Lagoon]. Retrieved February 19, 2023 from: https://www.google.com/maps/@28.0085815,-81.2056504,8z/data=!3m1!4b1!4m2!6m1!1s1hAgjzt-OuW40AoKM_PlvFMWYlT34LkE

Google. (2023b). [Google map of visitor centers in content analysis]. Retrieved February 19, 2023 from: https://www.google.com/maps/d/u/0/edit?hl=en&mid=1lBnwXMqxoOH0kTmwGmOWsfXvKo-G36aZ&ll=27.790954136755875%2C-80.5540843609375&z=7

Graham, T., & Abrahamse, W. (2017). Communicating the climate impacts of meat consumption: The effect of values and message framing. *Global Environmental Change*, *44*, 98–108. https://doi.org/10.1016/j.gloenvcha.2017.03.004

Greller, R., Mazzoli, M., Titcomb, E., Nelson, B., Paperno, R., & Markwith, S. H. (2021).

Environmental drivers of habitat use by common bottlenose dolphins (*Tursiops truncatus*) in the Indian River Lagoon, Florida, USA. *Marine Mammal Science*, *37*(2), 512–532. https://doi.org/10.1111/mms.12767

Ham, S.H. (1992). *Environmental interpretation: A practical guide for people with big ideas and small budgets.* Fulcrum.

Han, Q. & Liu, D. (2014). Macroalgae blooms and their effects on seagrass ecosystems. *Journal of Ocean University of China*, *13*(5), 791–798. https://doi.org/10.1007/s11802-014-2471-2

Hardisty, D. J., Johnson, E. J., & Weber, E. U. (2010). A dirty word or a dirty world? Attribute framing, political affiliation, and query theory. *Psychological Science*, *21*(1), 86–92. https://doi.org/10.1177/0956797609355572

Hayward, J. (2013). Evaluation: Rationale, methods, and negotiating the course. In: P. McKenna-Cress & J.A. Kamien (Eds.), *Creating exhibitions: Collaboration in the planning, development, and design of innovate experiences* (pp. 136-145). Wiley.

Hemminga, M.A. & Duarte, C.M. (2000). *Seagrass ecology.* Cambridge.

Indian River Lagoon National Estuary Program. (2019). *Looking ahead to 2030: A 10- year comprehensive conservation and management plan for the Indian River Lagoon, Florida.* https://onelagoon.org/wp-content/uploads/IRLNEP_Final-Draft-CCMP-REVISION_2018-12-07_LowRes__20200204.pdf

Indian River Lagoon National Estuary Program. (2022a). *Helping from home.* https://onelagoon.org/helping-from-home/

Indian River Lagoon National Estuary Program. (2022b). *Indian River Lagoon National Estuary*

Program communication plan FY 2022-2025. https://onelagoon.org/wp-content/uploads/Draft-CommPlan_3-Final-Draft-to-EPA.pdf

Indian River Lagoon National Estuary Program (2022c). *What's at risk?* https://onelagoon.org/importance/

Kendall-Taylor, N. (2017). Reframing biology: The power of explanation in improving individual and social outcomes. *Clinical Psychology, 24*(1), 69-73. http://doi.org/10.1111/cpsp.12187

Lapointe, B. E., Herren, L. W., Brewton, R. A., & Alderman, P. K. (2020). Nutrient over-enrichment and light limitation of seagrass communities in the Indian River Lagoon, an urbanized subtropical estuary. *Science of The Total Environment*, *699*, 134068. https://doi.org/10.1016/j.scitotenv.2019.134068

Lindgren, P. (2013). *Green sea turtle grazing seagrass* [Photograph]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Green_Sea_Turtle_grazing_seagrass.jpg

Maxwell, J.A. (2013). *Qualitative research design: An interactive approach (3rd edition).* Sage.

McHenry, J., Rassweiler, A., Hernan, G., Uejio, C. K., Pau, S., Dubel, A. K., & Lester, S. E. (2021). Modeling the biodiversity enhancement value of seagrass beds. *Diversity and Distributions*, *27*(11), 2036–2049. https://doi.org/10.1111/ddi.13379

McManus, P. (1991). Towards understanding the needs of museum visitors. In G.D. Lord & B. Lord (Eds.), *The manual of museum planning* (pp. 35-52). HMSO.

Miles, R. & Clarke, G. (1993). Setting off on the right foot: Front-end evaluation. *Environment and Behavior, 25*(6), 698-709.

Morris, L. J., Hall, L. M., Jacoby, C. A., Chamberlain, R. H., Hanisak, M. D., Miller, J. D., &

Virnstein, R. W. (2022). Seagrass in a changing estuary, the Indian River Lagoon, Florida, United States. *Frontiers in Marine Science*, *8*, 789818. https://doi.org/10.3389/fmars.2021.789818

Morris, L.J., Hall, L.M., Miller, J.D., Lasi, M.A., Chamberlain, R.H., Virnstein, R.W., & Jacoby, C.A. (2021).Diversity and distribution of seagrasses as related to salinity, temperature, and availability of light in the Indian River Lagoon, Florida. *Florida Scientist,* 83(2/3), 119-137.

Morris, L. J. & Virnstein, R.W. (2004). The demise and recovery of seagrass in the northern Indian River Lagoon, Florida. *Estuaries*, *27* (6), 915–22. https://doi.org/10.1007/BF02803418

National Association of Interpretation. (n.d.). *What is interpretation?* https://www.interpnet.com/NAI/interp/About/About_Interpretation/nai/_About/what_is_interp.aspx?hkey=53b0bfb4-74a6-4cfc-8379-1d55847c2cb9

National Research Council. (2009). *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, DC: The National Academies Press. https://doi.org/10.17226/12190

Office of Demographic and Economic Research. (2022). *County profiles.* The Florida Legislature. http://edr.state.fl.us/content/area-profiles/county/index.cfm

Ondiviela, B., Losad, I.J., Lara, J.L., Maza, M., Galvan, C., Bouma, T.J., & van Belzen, J. (2014). The role of seagrasses in coastal protection in a changing climate. *Coastal Engineering, 87*, 158-168. https://doi.org/10.1016/j.coastaleng.2013.11.005

Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M., Rouqurean, J.W., Heck, K.L.,

Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Olyarnik, S., Short, F.T., Waycott, M., & Williams, S.L. (2006). A global crisis for seagrass ecosystems. *BioScienc, 56*(12), 987-996.

Osborn, N. (2016). *Indian River Lagoon: An environmental history.* University Press of Florida.

Pearson, E. L., Lowry, R., Dorrian, J., & Litchfield, C. A. (2014). Evaluating the conservation impact of an innovative zoo-based educational campaign: 'Don't Palm Us Off' for orang-utan conservation. *Zoo Biology*, *33*(3), 184–196. https://doi.org/10.1002/zoo.21120

Ropret Homar, A. & Knežević Cvelbar, L. (2021). The effects of framing on environmental decisions: A systematic literature review. *Ecological Economics*, *183*, 106950. https://doi.org/10.1016/j.ecolecon.2021.106950

Schultz, P. W. (2014). Strategies for promoting proenvironmental behavior: lots of tools but few instructions. European Psychologist, 19, 107–117. https://doi.org/10.1027/1016-9040/a000163

Sime, P. (2005). St. Lucie Estuary and Indian River Lagoon conceptual ecological model. *Wetlands,* 25(40), 898-907.

Swim, J. K., Geiger, N., Fraser, J., & Pletcher, N. (2017). Climate Change Education at Nature-Based Museums. *Curator: The Museum Journal*, *60*(1), 101–119. https://doi.org/10.1111/cura.12187

Tetra Tech, Inc. (2022). *Save our Indian River Lagoon project plan 2022 update for Brevard County, Florida.* Brevard County Natural Resources Management Department. https://www.brevardfl.gov/SaveOurLagoon/ProjectPlan

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, *211*(4481), 453–458. https://doi.org/10.1126/science.7455683

Unsworth, R. K. F., Nordlund, L. M., & Cullen-Unsworth, L. C. (2019). Seagrass meadows support global fisheries production. *Conservation Letters*, *12*(1), e12566. https://doi.org/10.1111/conl.12566

Van Leuvan, N., Highleyman, L., Fujita, R., & Kellerman, A. (2022). *Making shift happen: Designing for successful environmental behavior change.* New Society Publishers.

Verissimo, D., MacMillan, D. C., & Smith, R. J. (2011). Toward a systematic approach for identifying conservation flagships: Identifying conservation flagships. *Conservation Letters*, *4*(1), 1–8. https://doi.org/10.1111/j.1755-263X.2010.00151.x

Virnstein, R.W., Mikkelsen, P.S., Cairns, K.D., & Capone, M.A. (1983). Seagrass beds versus sand bottoms: The trophic importance of their associated benthic invertebrates." *Florida Scientist, 46*(3/4), 363-381.

Warner, L. A., Rumble, J., Martin, E., Lamm, A. J., & Cantrell, R. (2015). The effect of strategic message selection on residents' intent to conserve water in the landscape. *Journal of Agricultural Education*, *56*(4), 59–74. https://doi.org/10.5032/jae.2015.04059

Appendix

Visual overview summary of seagrasses in the Indian Rive Lagoon Florida, including ecosystem services, causes of large-scale seagrass loss, and proposed management actions.