Coral Reefs and Climate Change: Examining Two Institutional Approaches to Managing a Novel Marine Ecosystem

by

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Abstract

Much of Florida's economy is tied to the third-largest barrier reef in the world, the Florida Reef Tract. However, because of anthropogenic threats, it is not the thriving ecosystem it once was, and its persistence requires different management strategies than what may have been conventionally considered. Two entities have emerged to address this problem: the Florida Keys National Marine Sanctuary and the Southeast Florida Coral Reef Initiative. I therefore ask: How does coral reef management vary over the different spatial extents and structures of these organizations? And, how do these organizations vary in incorporating important aspects of novel ecosystem management? Using 1122 statements from news documents, public meeting transcripts, and stakeholder interviews, I compare the institutional elements of each organization and determine the importance they place on five management considerations, which improve novel ecosystem management. My results indicate significant institutional differences between the two, one marked by a focus on regulations and authority and the other by a focus on data collection, and preparedness.

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List of Abbreviations

CO_2	Carbon Dioxide
DEP	Florida Department of Environmental Protection
ECA	Kristin Jacobs Coral Reef Ecosystem Conservation Area
EPA	Environmental Protection Agency
FKNMS	Florida Keys National Marine Sanctuary
FWC	Florida Fish and Wildlife Conservation Commission
GCRMN	Global Coral Reef Monitoring Network
NOAA	National Oceanic and Atmospheric Administration
SEFCRI	Southeast Florida Coral Reef Initiative
U.S.	United States

1. Introduction

Florida is one of the fastest urbanizing states in America (DeSteno, 2020). It is also home to the third-largest barrier reef in the world, the only ecosystem of its kind in the contiguous United States (U.S.). Much of Florida's economy is closely linked to this valuable natural resource, which generates billions of dollars annually in goods and services (TBD Economics, 2019). Unfortunately, coral reef ecosystems are incredibly vulnerable to many environmental stressors, most of which are anthropogenic (Hoegh-Guldberg et al., 2017). Historically, pollutants such as run-off from coastal development, improper waste management, and agricultural production heavily impacted the health of Florida's coral reefs. But today, the single greatest threat facing the Florida Reef Tract is undoubtedly climate change (Hughes et al., 2017a). The Florida Reef Tract we see today is not the thriving ecosystem it once was. It is now a "novel ecosystem," defined by many significant changes to its species configurations, ecological interactions, and overall functionality (Clement & Standish, 2018; Toth et al., 2019). Therefore, ensuring the Florida Reef Tract's persistence requires management strategies that address the unique challenges that novel ecosystems present (Clement & Standish, 2018).

Perplexingly, the processes that drive many environmental stressors, such as commercial fishing and agriculture, are also entrenched in Florida's thriving economy, involving countless stakeholders. Many of these stakeholders also rely on the ecosystem services that the Florida Reef Tract provides, such as tourism and recreation. Therefore, the management of the Florida Reef Tract can be highly divisive, which puts managers in a difficult situation. While no single strategy can satisfy all stakeholders, there are many that attempt to foster collaboration across diverse actors, interests, regions, and institutions. Two fundamentally different and regionally distinct management entities have emerged to manage the Florida Reef Tract: 1) The Florida Keys National Marine Sanctuary (FKNMS), and 2) the Southeast Florida Coral Reef Initiative (SEFCRI). Given that contemporary management needs to adapt rapidly to changing and uncertain ecological conditions, it is important to know how and why management evolves. Thus, my research asks two research questions:

1. How does coral reef management vary over the different spatial extents and organizational structures of the FKNMS and SEFCRI?

2. How do these organizations vary in incorporating important aspects of novel ecosystem management?

To answer these questions, I used a comparative case study research design and mixed methods to collect my data. Data included transcripts from advisory meetings, newspaper articles, policy documents (e.g., press releases), and interviews with key managers and stakeholders. Using two theoretical frameworks and a qualitative coding process, these data were broken down into individual comments from SEFCRI ($n = 581$) and the FKNMS ($n = 541$). Each comment was also classified as positive or negative to highlight criticisms held by stakeholders and managers. To collect these data, the appearance of mass coral bleaching and other novel characteristics were used to indicate the arrival of climate change and the beginning of a new era in coral reef conservation. I included this distinction because it helped limit the data collection to a time when novel impacts were abundant (1996 - present).

I coded my data according to a Novel Ecosystem Framework developed by Clement and Standish (2018). This framework identifies five important concepts for managing novel ecosystems that must be accounted for by management organizations like SEFCRI and the FKNMS. These include: 1) *Administrative Competence* (i.e., is management effective?); 2) *Buffering* (i.e., is management adequately prepared?); 3) *Culture and Norms* (i.e., is management inclusive?) 4) *Issue Framing* (i.e., is management focused on contemporary issues?) and 5) *Power and Authority* (i.e., is management well-organized and respected?). I used mentions of each important concept for novel ecosystem management (i.e., the building blocks of the framework) as proxies to gauge their relative importance for each organization. In doing so, I was able to compare the FKNMS and SEFCRI's distinct approaches to management.

In addition to Novel Ecosystems, I adopted several key concepts from another theoretical framework, Pahl-Wostl's Framework for Adaptive Governance (2009), which classifies magnitudes of change within management organizations. To do this, Pahl-Wostl conceptualizes management organizations as *institutions*, which she defines as the rules that govern the behavior of organizations like SEFCRI and the FKNMS. She then applies a theory of learning, which suggests that institutions improve over time using a process of iterative learning, where knowledge grows and eventually results in fundamental changes to institutional values or ideologies. Therefore, incorporating this theoretical framework into my analysis helps classify progress and learning within SEFCRI and the FKNMS.

Overall, my results show that Administrative Competence was the most important concept for managing a novel ecosystem for both the FKNMS and SEFCRI. Administrative Competence reflects how important the ultimate goal of conservation is to each organization. Therefore, these results indicate that both organizations heavily value the preservation of the Florida Reef Tract. However, they approach this goal in different ways.

SEFCRI's coral reef management was characterized by informal institutions, defined as management that included a large network of governmental and non-governmental actors (e.g., state agencies and nonprofits, respectively). This management style lacked rule-making authority. Instead, SEFCRI incorporated contemporary issues impacting the reef into their management considerations, focusing on future planning and generating new projects aimed at reducing ecological uncertainty. Specific activities to reduce uncertainty included generating research and knowledge about the northern reaches of the Florida Reef Tract, which until recently was largely unknown and informally managed, if at all. SEFCRI also focused heavily on broad public outreach initiatives to improve awareness of, and appreciation for, the northern reaches of the Florida Reef Tract. Finally, SEFCRI emphasized leadership roles among many actors, capitalizing on its decentralized, collaborative approach to management, deriving power from multiple actors within its network.

Alternatively, I found the FKNMS to be a formal institution, defined by its top-down, authoritative approach to management, which relied heavily on governmental actors, laws, and regulations. Given this formal structure, regulatory enforcement and procedural changes were common and important. The FKNMS used existing regulations, management plans, and results to iteratively move management within the concepts for managing a novel ecosystem. Past projects and tangible results were also used to inform future management decisions rather than collecting information for the first time. The FKNMS also strongly emphasized stakeholder engagement rather than public outreach, meaning that the FKNMS focused on a more narrow group of actors whose livelihoods depend on the reefs of the Florida Keys. Ultimately, the FKNMS was characterized by regulatory actions, centralized leadership, and active management concerns (i.e., concerns related to marine zoning and regulatory enforcement versus concerns associated with planning for future interventions).

Finally, there were key differences and similarities in iterative learning between the two organizations. The FKNMS focused more heavily on day-to-day management actions than SEFCRI. As a result, those actions eventually led to more fundamental changes down the line. However, both SEFCRI and the FKNMS consistently questioned why they approached management in a certain way, which helped to iteratively improve management and move towards setting new goals and objectives with novel ecosystems in mind.

This comparative case study helps to identify areas where institutions can manage novel ecosystems. This understanding is essential in a context like the Florida Reef Tract, where the ecosystem is so vast that multiple institutions, municipalities, types of governance, and actors are involved. By highlighting similarities and differences between the FKNMS and SEFCRI, my findings help to explain how these institutions interact and approach conservation. This information can inform managers and stakeholders and facilitate cooperation. The effects of climate change on the Florida Reef Tract have created an opportunity to explore contemporary environmental governance.

Filling this information gap underpins the success and longevity of coral reef conservation. To my knowledge, this research is the first systematic, theory-relevant, comparative case study of the two leading organizations responsible for managing Florida's coral reefs. Before my research, there was limited understanding of how these organizations function and adapt to the new environmental realities under climate change, generating novel ecosystems. This research supplements the current literature on coral reef management in southeastern Florida and may help inform the management of similarly threatened ecosystems worldwide while setting the stage for further research on institutions and novel ecosystems.

2. Literature Review

(2.1) Coral Reefs

The ecological and economic importance of coral reefs cannot be overstated. These rare and vulnerable ecosystems are aptly described as "global life-support systems," sustaining over 500 million people and 25% of all marine species worldwide (Henkel, 2010; Moberg & Folke, 1999). Although tropical coral reefs cover less than 0.5% of the ocean floor, it is clear that these are among the most diverse and productive ecosystems on the planet (Hoegh-Guldberg et al., 2017; Moberg & Folke, 1999). Among the many ecosystem services coral reefs provide, they generate robust tourism industries, support vast commercial fisheries, and protect coastlines during severe storm events. A recent evaluation concluded that in the U.S. alone, coral reefs safeguard more than 18,000 people from coastal flooding every year (Storlazzi et al., 2019).

The state of Florida is home to the third-largest barrier reef in the world, the Florida Reef Tract, the only ecosystem of its kind in the contiguous United States (Finkl & Andrews, 2008). Much of Florida's economy is closely linked to this valuable natural resource, which generates billions of dollars annually in goods and services (Wynveen et al., 2013). Much of the Florida Reef Tract is managed by the Florida Keys National Marine Sanctuary (FKNMS), which was established in 1990. In 2015 the FKNMS contributed 38,111 jobs and $2.57 billion to Florida's economy (TBD Economics, 2019). Although about two-thirds of Florida's 350-mile reef tract is contained within the FKNMS, significant portions extend as far north as St. Lucie Inlet in Martin County (Douglas, 2020). Until recently, the northern reaches of the Florida Reef Tract lacked a cohesive management strategy similar to that of the Florida Keys National Marine Sanctuary. Now, this section is cooperatively managed under the Florida Department of Environmental Protection (DEP) and the Southeast Florida Coral Reef Initiative (SEFCRI) (Reisewitz & Harper, 2013).

Due to the prevalence of coral reefs in southern Florida, many stakeholders are significantly invested in the health and productivity of these vital ecosystems (Cinner et al., 2012). However, coral reefs are fragile and face many anthropogenic threats such as climate change, pollution, overfishing, and mechanical damage (e.g., ship groundings, oil drilling, anchor damage, trawling, etc.) (Frys et al., 2020). These stressors are often synergistic, compounding reef degradation and making conservation efforts difficult to implement (Dustan, 2003). Over the last four decades, coral reefs have entered a state of precipitous decline. Approximately 30% of all coral reefs have been severely damaged, and it is speculated that no pristine coral reefs exist today (Anthony et al., 2020; Dustan, 2003; Hughes et al., 2003). Furthermore, it is estimated that by 2030, 60% of all coral reefs will have been lost (Hughes et al., 2018b). Due to the scale of the crisis facing coral reefs and the amalgamation of societal hurdles conservation planning must overcome, management strategies can be highly contentious and incredibly hard to implement regionally. Despite the consensus that we must save coral reefs, time is quickly running out.

In recent decades, climate change has taken center stage as the single greatest threat facing modern coral reefs (Hughes et al., 2017a, 2017b). Atmospheric greenhouse gas concentrations have been exponentially increasing since the Industrial Revolution. The concentration of one commonly recognized contributor, carbon dioxide (CO_2), has risen at 250 times its natural rate following the last ice age (NASA, 2020). Currently, the measurement of atmospheric CO_2 stands at 415 ppm, the highest concentration in 650,000 years (NASA, 2020). As a result, the earth's atmosphere and oceans are warming at an unprecedented rate (Hopkin, 2005). Over 90% of the warming that the planet has experienced in the last 50 years has occurred in the oceans. From 1971 to 2010, 63% of the total increase in stored heat was captured by the oceans' upper sun-lit layers (Dahlman & Lindsey, 2021). Therefore, the oceans' usefulness as a reservoir for thermal energy and CO_2 may spell disaster for coral reefs. Coral reef ecosystems are among the most climate-sensitive on earth, requiring narrow temperature ranges to survive, making them extremely vulnerable to unprecedented warming events.

One disastrous effect of climate change, coral bleaching, has become a well-documented and highly publicized phenomenon (Dispensa & Brulle, 2003; Hughes et al., 2017a, 2018a, 2018b; Manzello, 2015). Coral reefs are often characterized by their scleractinian species, otherwise known as "reef-building" or "stony" corals. As their colloquial description implies, these species play a critical role in the formation of coral reefs (Stanley, 1981). Coral reefs are composed of hundreds of different reef-building species, and each coral colony is composed of thousands of genetically identical animals called polyps. Stony corals grow through a process of accretion, producing layered calcium carbonate ($CaCO_3$) skeletons that protect the delicate coral polyps, secure them to the substrate, and as a result, add structural complexity to the reef (Roff, 2019). Because corals are sessile organisms (i.e., immobile), they rely on two energy sources. First, they capture microscopic organisms in the water column using small tentacles armed with stinging cells called nematocysts. Second, corals depend on a symbiotic relationship with several specific groups of dinoflagellate microalgae (i.e., single-celled algae) called zooxanthellae.

Zooxanthellae produce oxygen and energy for corals via photosynthesis in exchange for shelter and shared nutrients. They also give corals their often-vibrant coloration. Because physically capturing microorganisms only provides corals with about 10% of their energy, the zooxanthellae are essential for their survival (Forsman, 2005; Weis, 2008). However, when exposed to adverse environmental conditions for prolonged periods of time (e.g., warming ocean temperatures), corals exhibit a natural stress response known as "bleaching." During this process, coral colonies expel the symbiotic zooxanthellae, revealing their underlying white calcium carbonate skeletons and losing these vital energy sources. If the environmental stressors are not alleviated, coral bleaching events often result in high rates of coral mortality (Wagner et al., 2010). Unfortunately, due to global warming's rapid progression, these events are no longer isolated or rare (Hughes et al., 2003; Manzello et al., 2007).

The extent and severity of coral bleaching are the result of above-average sea-surface temperatures, not short-lived temperature fluctuations. While many corals are resilient to brief heatwaves, sustained elevations in sea surface temperatures can cause high mortality in coral

reefs. It has been shown that prolonged exposure to mean temperatures as little as ~1°C (1.8°F) above the regional summer maximum can lead to coral bleaching. As a result, coral colonies often perish before conditions stabilize (Hoegh-Guldberg, 1999; Hughes et al., 2003; Magel et al., 2019). In 2013 the Intergovernmental Panel on Climate Change (IPCC) predicted a 1-4°C (1.8-7.2°F) increase in mean global ocean temperatures by 2100—a bleak prognosis for coral reefs.

Beginning in 1987, six mass bleaching events along the Florida Reef Tract have significantly diminished coral reef ecosystem functionality by fragmenting and destroying vast swaths of habitat (Manzello, 2015). For example, a program administered by the U.S. Environmental Protection Agency (EPA), the Florida Marine Research Institute, and the National Oceanic and Atmospheric Administration (NOAA) found that in some areas, between 1996 and 2000, the Florida Keys archipelago lost up to 36% of its coral cover (Precht & Miller, 2007). However, although extensive, this assessment began long after substantial coral losses had already occurred for a variety of reasons, including (1) the Florida Reef Tract's proximity to massive population centers; (2) its propensity for hurricane encounters; (3) the unprecedented over-exploitation of its natural resources via recreational and commercial interests; (4) coastal development resulting in profound disturbances to water quality; (5) altered hydrology and nutrient flows from the everglades; and (6) climate change (Jackson et al., 2014). These losses were particularly severe among the branching acroporid corals which had historically dominated the Florida Reef Tract. Staggeringly, a study of Looe Key, a popular reef and protected area in the Florida Keys, found that populations of *Acropora palmata* and *Acropora cervicornis* (the two most prominent acroporid species commonly known as Staghorn and Elkhorn coral) declined by 93% and 98% respectively between 1983 and 2000 (Miller et al., 2002; Precht & Miller, 2007).

The cause of this decline, while exacerbated by climate change and the disappearance of critical fish and invertebrate species, began in the late 1970s with the emergence of White Band Disease, a suspected result of the poor water quality in the region at the time (Jackson et al., 2014). According to a report published by the Global Coral Reef Monitoring Network

(GCRMN), as of 2010, the Florida Reef Tract's total coral coverage was under 10% and declining rapidly. The GCRMN described the status of the Florida Reef Tract as "a worst-case scenario in which unprecedented population growth and inadequate governance and regulations have resulted in the critical endangerment of an entire coral reef ecosystem." (Jackson et al., 2014). By 2020, news sources began reporting the remaining percentage to be less than 5%, and even as little as 2%, of the historic coral cover that was once present in the Florida Keys, indicating persistent degradation (Chinn, 2020; Huang, 2019; Letzter, 2019).

Although many organizations are currently working to save the Florida Reef Tract and other imperiled coral reefs worldwide, it is now clear that conventional management and intervention strategies will not be enough to mitigate the projected losses (Anthony et al., 2020; Jackson et al., 2014). Therefore, coral reefs are in dire need of innovative conservation governance strategies to curb their catastrophic decline and protect the valuable ecosystem services they provide.

(2.2) Adaptive Governance

In the face of rapid environmental change on a global scale, there has been an interdisciplinary movement among scientists to reconsider how ecosystems are managed and governed in the Anthropocene, the age in which human activity has become the dominant influence on the Earth's climate and environment. As the human population has continued to grow, interactions between people and the environment have become more common and more complicated. These interactions are often described as social-ecological systems (Folke, 2006; Folke et al., 2005; Ostrom, 2009; Walker et al., 2004). Elinor Ostrom, a pioneer of the social-ecological system concept, likens the complexity of a natural resource system (e.g., an ecosystem with many different resources, users, and types of environmental governance) to the complexity of biological organisms, where many subsystems interact to produce feedback loops which compose a greater whole (Ostrom, 2009). While this concept was initially developed to help explain the interconnected nature of people and their environment, it has since become a

staple within the natural resource literature, including topics ranging from cattle ranching, forestry, coral reef conservation, and adaptive governance (Berkes et al., 2000; Fischer, 2018; Herrero-Jáuregui et al., 2018; Pendleton et al., 2016; Walker et al., 2004).

Adaptive governance is a type of environmental governance that has increased in popularity since the turn of the century, becoming a widely discussed and widely implemented approach to conservation (Chaffin et al., 2014). Before unpacking adaptive governance, we must briefly describe its precursor, environmental governance, which broadly includes the regulations, processes, and organizations political actors rely upon to achieve desirable ecological outcomes (Lemos & Agrawal, 2006). But in this context, governance and government are not the same thing. In addition to direct governmental intervention, such as an agency instituting catch-limit regulations on a fishery, environmental governance includes other actors such as communities, businesses, and NGOs (Lemos & Agrawal, 2006). Additionally, institutions, defined as the formal and informal rules that guide management actions, are a critical aspect of environmental governance, helping to explain the behavior of diverse actors in social-ecological systems and the collective management of their natural resources (Paavola, 2007; Pahl-Wostl, 2015).

However, the ways in which institutions interact and evolve within social-ecological systems and the role they play in environmental governance has become a critical concept (Bennett & Satterfield, 2018; Pahl-Wostl, 2015; Young, 2008). Therefore, perhaps the best definitions acknowledge both the role of institutions and the ecological breadth of the topic. Ultimately, "environmental governance is a system of institutions, including rules, laws, regulations, policies, and social norms, and organizations involved in governing environmental resource use and/or protection, [including] a variety of different approaches" (Chaffin et al., 2014). One such approach to environmental governance has evolved to manage social-ecological systems that are prone to high levels of complexity and uncertainty, and involve complex institutional dynamics and actor relationships—adaptive governance.

Adaptive governance at its core is about learning to respond to environmental disturbances in ways that build resilience within social-ecological systems. Resilience is defined as the ability of a system to absorb change while maintaining its stability. In other words, adaptive governance refers to learning-based approaches to environmental governance, where knowledge and understanding are used over time to improve management practices across multiple institutional, governmental, spatial, and temporal scales, enabling a social-ecological system to overcome rapid, unpredictable changes (Folke, 2006; Schultz et al., 2015). Additionally, some authors have highlighted adaptive governance as a departure from traditional governance. It relies heavily on collective decision-making, which involves multiple interests, community-based initiatives, and integrative science to appraise the effectiveness of environmental policies (Brunner et al., 2005). Given the interdependence of coral reefs and coastal communities, it comes as no surprise that a large body of literature has accumulated which uses adaptive governance as a basis for managing marine resources, including wetlands, fisheries, and especially, coral reefs (Cinner et al., 2012; Cvitanovic et al., 2015; Dunning, 2021; Hughes et al., 2010; Mcleod et al., 2019; Scholz & Stiftel, 2010; Schultz et al., 2015; Österblom & Folke, 2013).

Worldwide, adaptive governance has been used to design and assess many coral reef management interventions such as marine protected areas (Ban et al., 2011; Evans et al., 2011) and varying types of co-management strategies implemented between local communities and governments (Cinner et al., 2012; McClanahan et al., 2006). It has even been used as a tool to repeatedly assess the largest coral reef ecosystem on earth, the Great Barrier Reef (McCook et al., 2010; Morrison, 2017). Because of the sensitivity of coral reefs to environmental disturbances such as water quality, temperature fluctuation, and ocean acidification, adaptive governance often centers around the need to build resilience within these systems (Hughes et al., 2003). In this context, resilience is the ability of a coral reef ecosystem to absorb change and manage disturbance while maintaining its ecological stability (Holling, 1973). This has also been referred to as the ecosystem's "adaptive capacity" (Anthony et al., 2015; Cinner et al., 2018; Pendleton et al., 2016). The resilience of a coral reef varies drastically, depending on where it is

located, its biological composition, and what disturbances are present (Roff & Mumby, 2012). Multiple studies have highlighted the necessity of assessing an ecosystem's resilience or adaptive capacity to help customize management strategies to best-fit the ecosystem's needs; this process has been aptly termed "adaptive resilience-based management" (Graham et al., 2013; Hughes et al., 2010; Mcleod et al., 2019).[1]

A recent literature review of adaptive governance highlights a mismatch between different types of institutions and their approaches to conservation governance when managing social-ecological systems (Chaffin et al., 2014). For example, centralized governance often fails when working within large-scale ecosystems due to jurisdictional overlap. In contrast, bottom-up collective approaches to governance, such as polycentric governance, may work better in these instances (Chaffin et al., 2014). This is also termed "institutional fit," where adaptive governance is used to assess or improve institutions and their modes of governance to best fit the scenario and achieve desirable environmental outcomes (Lockwood et al., 2012; Rijke et al., 2012; Sternlieb et al., 2013). For example, in a social-ecological system with a high degree of uncertainty, such as a coral reef in the face of climate change, many approaches may be employed to achieve the same outcome: conservation. However, these approaches need to be assessed to determine which aspects are the most effective for achieving coral reef conservation. This concept is expounded upon further by Clement et al. (2016) and Clement and Standish (2018), who employ a conceptual framework to assess the fitness of adaptive governance strategies in the context of novel ecosystems, like the Florida Reef Tract.

(2.3) Novel Marine Ecosystems

It is unlikely that coral reefs will ever return to their pristine state prior to the Anthropocene (Graham et al., 2013). Furthermore, it is equally unlikely that the conventional management strategies, such as marine protected areas, which were historically used to limit overfishing, reduce pollution, and restore species assemblages, will be capable of addressing the

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[1] See (Bang et al., 2021) for a recent review of these types of resilience assessments and their relevance to coral reef governance.

broader effects of climate change (Graham et al., 2014; Hughes et al., 2017b). Until recently, coral reef conservation and management have primarily focused on reestablishing historical, ecological, and social baselines within damaged ecosystems (Morrison et al., 2020; Rogers et al., 2015). However, as favorable environmental conditions continue to deteriorate for coral reefs, these baselines continue to shift (Rogers et al., 2015). Termed "shifting baselines syndrome," the composition of coral reefs and the requirements that must be met in order for them to persist have changed dramatically, requiring new management prescriptions (Braverman, 2020; Graham et al., 2013).

Some literature argues that coral reefs have entered a transitional state, wherein dramatic changes to species composition have been accompanied by alterations to the fundamental processes and interactions that underpin ecosystem functionality (Clement & Standish, 2018; Graham et al., 2014; Hobbs et al., 2013). For example, anthropogenic disturbances such as coral bleaching and coral disease have homogenized the Florida Reef Tract's species assemblages, reducing its natural structural complexity and imperiling its ecosystem services (Burman et al., 2012). In some areas, as the once-dominant reef-building corals such as *A. cervicornis* (Staghorn coral) and *A. palmata* (Elkhorn coral) disappeared, faster-growing, opportunistic species of sponges and algae quickly took their place; causing a shift away from species-rich coral-dominated reefs to simpler (i.e., homogenized) algae-sponge-dominated reefs (Chaves-Fonnegra et al., 2018). These new ecosystems are appropriately described as novel ecosystems, or in the case of coral reefs, novel marine ecosystems.

The concept of *novel* ecosystems (also referred to as 'no-analog' or 'emerging' ecosystems) finds its roots in 20th-century ecology, derived from three concepts: (1) the interactions of biotic and abiotic characteristics within ecosystems (i.e., living organisms and their environment affect one another); (2) individualism within communities (i.e., plants and animals respond to their environment independently of one another and are therefore dynamic); and (3) anthropogenic changes to ecosystem functionality (i.e., humans often directionally and permanently change their environment) (Hobbs et al., 2013). While Chapin and Starfield (1997)

first coined the term "novel ecosystem," I utilize one of the most relevant and widely cited definitions available in contemporary literature:

> "A novel ecosystem is a system of abiotic, biotic, and social components (and their interactions) that, by virtue of human influence, differ from those that prevailed historically, tending to self-organize and manifest novel qualities without intensive human management." (Hobbs et al., 2006; Hobbs et al., 2013).

Contemporary research has made it clear that adaptive management strategies are necessary to save coral reefs and the people who depend upon them (Cinner et al., 2016; Comte & Pendleton, 2018; Morrison et al., 2020). However, while the seminal works by Hobbs et al. (2006, 2009, 2013) contend that human activity must contribute to the emergence of a novel ecosystem, but not its preservation, their explanation is rooted in terrestrial ecology, where novel ecosystems might include agricultural plantations or habitat restoration initiatives which require constant upkeep (i.e., direct human intervention). For example, a banana plantation would not be considered a novel ecosystem because it requires human management to persist. Without intervention, the surrounding forest would eventually retake that land, and the ecosystem would revert to its original state. Therefore, the key takeaway from Hobbs et al. (2006, 2009, 2013) is that novel ecosystems arise as a response of the biosphere to anthropogenic influences, and the resulting ecosystem characteristics are not continually dictated by humans (Hobbs et al., 2013). Also, the recognition that a threshold has been crossed and the historical state (i.e., historical baseline) of an ecosystem cannot be reestablished is essential when determining whether a novel ecosystem exists (Bulleri et al., 2020; Hobbs et al., 2009).

While drawing many parallels to the concepts of novel terrestrial ecosystems, novel marine ecosystems are somewhat nuanced and occupy a niche in the novel ecosystem literature (Braverman, 2020; Graham et al., 2013, 2014; Hobbs et al., 2013; Morrison et al., 2020; Toth et al., 2019). Climate change, global trade, and the over-exploitation of marine resources, worsened by the concentration of human population centers along coastlines, have undoubtedly contributed to the creation of novel ecosystems (Hobbs et al., 2013). Some examples of possible drivers include: 1) the constant uptake, transport, and release of ballast water along shipping lanes,

which has long been considered a vector for invasive species and the spread of coral diseases (Wisconsin Sea Grant, 2019); 2) the aquarium trade, which is suspected of introducing the invasive lionfish, a voracious and indiscriminate predator with few natural enemies, to the Florida Reef Tract (Johnston & Purkis, 2011); and 3) the overfishing of valuable marine species, which has triggered trophic-cascades with potentially far-reaching impacts (Daskalov et al., 2007).[2] When it comes to coral reef ecosystems and their rapid decline over the last 50 years, they have become excellent candidates for potential classification as novel ecosystems (Graham et al., 2014).

The marine novel ecosystem concept is still emerging, and for some reefs, it is still possible that they have not reached a tipping point and may return to their historical conditions (Bulleri et al., 2020). For example, thermal tolerance and other favorable genetic traits, such as increased heat tolerance, may enable some coral reefs to adapt to rapidly changing conditions, leaving those reefs functionally intact and unchanged. For example, the northern Red Sea is considered by some to be a "coral reef refugia" from global warming and ocean acidification due to the genetically robust, heat-tolerant coral populations that inhabit the area (Fine et al., 2019). However, for most of the world, even under the most favorable predictive IPCC climate change models, coral reefs will be unable to keep up with the unprecedented rates of warming, given what we know about their life-history and characteristics (Kubicek et al., 2019). With this information in mind, let us return to the Florida Reef Tract, where overfishing, pollution, disease, recruitment failure, invasive species, and climate change have arguably resulted in the emergence of a novel coral reef ecosystem, necessitating unique management strategies capable of addressing these pernicious anthropogenic threats (Aronson, 2007; Graham et al., 2014; Toth et al., 2019).

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[2] "Trophic cascades are powerful indirect interactions that can control entire ecosystems. Trophic cascades occur when predators limit the density and/or behavior of their prey and thereby enhance survival of the next lower trophic level." (Silliman & Angelini, 2012) For example, the elimination of a key predator species could allow for the proliferation of an otherwise well-controlled prey species, which could result in an imbalance which causes damage to the local habitat.

3. Case Context

(3.1) Novel Aspects of The Florida Reef Tract

As previously mentioned, the decline of the Florida Reef Tract and its transition towards a novel ecosystem mainly began in the 1970s with a severe decline in foundational coral species that had been present in the region since the late Pleistocene, namely three coral taxa, *Acropora palmata, Acropora cervicornis, and Orbicella spp*. (Pandolfi & Jackson, 2006; Precht & Miller, 2007; Toth et al., 2019). These species were common throughout the Caribbean but have quickly begun to be replaced by opportunistic species of fleshy macroalgae, sponges, and other non-reef-building organisms (Alvarez-Filip et al., 2013; Cramer et al., 2020; Loh et al., 2015). In some cases, these species are faster growing, more stress-tolerant, and may be unsusceptible to certain diseases or better genetically equipped to endure thermal stress (Darling et al., 2012; Toth et al., 2019). Therefore, they are well-adapted to anthropogenic conditions and tend to reproduce quickly (Darling et al., 2012). However, they also fail to fill the same functional roles that scleractinian (i.e., reef-building) coral species do, such as adding structural complexity through calcium carbonate accretion, reducing wave energy, and providing habitat for countless marine species (Alvarez-Filip et al., 2011; Kuffner & Toth, 2016; Spalding et al., 2014). Without three-dimensional structural complexity, coral reefs lose much of the functionality that enables the suite of ecosystem services they provide (Burman et al., 2012; Kuffner & Toth, 2016; Storlazzi et al., 2019). As these reef-building species disappear and are replaced, biological, chemical, and physical processes of reef erosion and deterioration accelerate, resulting in a net loss of calcium carbonate and the eventual overall flattening of the reef tract (Perry & Alvarez-Filip, 2018; Perry et al., 2015; Toth et al., 2019).

This decline, especially among the branching acroporid corals (i.e., *A. cervicornis and A. palmata*), is attributed mainly to White Band Disease, one of many aggressive diseases and syndromes that affect corals throughout the Caribbean (Cramer et al., 2020; Weil, 2004). While the cause(s) of these afflictions, even some of the most widespread, remain mysterious, some

have been associated with bacterial infection (Weil et al., 2006). The increasing frequency and severity of these outbreaks appear to result from both poor water quality and warmer ocean temperatures (Estrada-Saldívar et al., 2020; Precht & Miller, 2007). Unfortunately, disease outbreaks, including a severe new coral disease sweeping the Florida Reef Tract (Stony Coral Tissue Loss Disease (SCTLD)), are still emerging, affecting new reef-building coral species, and appear to be exacerbated by climate change (Randall & Van Woesik, 2017; Sokolow, 2009).

Disease outbreaks in the late 20th century were not limited to corals. In 1983-1984, the mass mortality of *Diadema antillarum*, a herbivorous sea urchin, the long-spined sea urchin, was attributed to an unidentified pathogen (Cramer et al., 2020; Weil et al., 2006).[3] This keystone species was responsible for helping to control fleshy macroalgae populations in conjunction with herbivorous fish populations (Lessios, 2016).[4] When given the opportunity, fleshy macroalgae can easily out-compete slower-growing coral species (McManus & Polsenberg, 2004). Because so many corals had already been destroyed, opening up "free real estate" for encroaching organisms, the die-off of long-spined sea urchins contributed to a massive incursion of macroalgae that swept the Caribbean, facilitating a phase-shift in coral-algal species composition (Cramer et al., 2020; Greenstein et al., 1998; Hughes, 1994; Jackson et al., 2014; Lirman, 2001).[5] The urchin population has yet to fully rebound. As of 2016, the population had reached approximately 12% of their historic numbers, indicative of the severity of the die-off and the lasting impact on the ecosystem (Lessios, 2016). Furthermore, their natural recovery has been significantly hampered by the reduced structural complexity seen on the reef, partially a consequence of their disappearance (Bodmer et al., 2021; Pilnick et al., 2021).

Whether keystone herbivorous fish species were overfished in Florida when the sea urchin population began to decline remains the topic of some debate (Jackson et al., 2014;

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[3] Herbivorous animals feed on autotrophs such as plants and algae (National Geographic Society, 2012).
[4] "Keystone species are those species whose importance to an ecosystem's structure, composition, and function is disproportionately large relative to their abundance […] Well-studied examples include sea stars, beavers, bears, corals, elephants, and hummingbirds." (Nuñez & Dimarco, 2010)
[5] In ecology, and in the context of coral reefs, a phase-shift refers to a significant change in community structure among organisms (Done, 1992).

McClenachan, 2013). If they were overfished, this might have contributed to the abundance of fleshy macroalgae in the region following the disappearance of the sea urchins. Regardless, in addition to the disappearance of critical herbivorous species on the Florida Reef Tract, overfishing has become a significant problem in Florida. The removal of top predators, including groupers, snappers, and sharks, has likely caused one or more trophic cascades, affecting the structure and function of reef-fish species assemblages, including herbivorous fish (McClenachan, 2009; Pandolfi et al., 2003; Precht & Miller, 2007). As a result, these changes have indirectly contributed to alterations to benthic invertebrate species compositions, such as increasing populations of encroaching sponges, which would otherwise become prey for herbivorous species (Loh et al., 2015).

While algal cover and abundance are associated mainly with the lack of herbivores, poor water quality is also a significant influencing factor (Jackson et al., 2014; Precht & Miller, 2007). Nutrient enrichment (i.e., nutrient loading) has also driven algal blooms. Nutrient enrichment is just one result of increased urbanization, agriculture, and changes to the hydrological flow regimes within the Everglades ecosystem. These alterations, especially the changes to hydrology in Southern Florida, have significantly impacted the regional water quality of the Florida Keys. Unfortunately, without active restoration, these influences threaten to remain permanent causes of disturbance.

(3.2) The Florida Keys National Marine Sanctuary

Despite the many environmental stressors that have impacted the Florida Reef Tract, there have been significant strides made towards its conservation. Perhaps the most well-known organization, the Florida Keys National Marine Sanctuary (FKNMS), was established in 1990 under the Marine Protection, Research, and Sanctuaries Act of 1972.[6] Although the FKNMS was formed before the advent of mass coral bleaching in the Caribbean, its creation was not without precedent. Many of the environmental changes seen on the reef

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[6] Now called the Florida Keys National Marine Sanctuary and Protection Act (P.L. 101-605; U.S. Department of Commerce, 2007).

today were already underway at that time (Kuffner et al., 2015; Toth et al., 2019). Initial discussions on the conservation of the Florida Reef Tract began in 1957 and quickly resulted in the formation of John Pennekamp Coral Reef State Park, the first underwater park of its kind in the United States (U.S. Department of Commerce, 2007). However, following renewed environmental concerns surrounding pollution, resource exploitation, and user conflicts within the park, the Key Largo National Marine Sanctuary was established in 1975, increasing the amount of reef tract that fell within protected areas. In addition to John Pennekamp Coral Reef State Park, this sanctuary extended 103 square nautical miles south from Carysfort Reef to Molasses Reef (Figure 6, Appendix B). Shortly thereafter, Looe Key National Marine Sanctuary was established in 1981 but only covered a limited 5.32 square nautical miles (U.S. Department of Commerce, 2007). While these protected areas were incremental steps towards marine conservation, they also paved the way for the eventual creation of the Florida Keys National Marine Sanctuary that we see today.

Concurrently, several ecological crises began to develop—episodic coral bleaching, widespread disease, and severe declines among multiple keystone species quickly became the penultimate triggers for environmental reform throughout the early 1980s (Frys et al., 2020; Gregg, 2013). Given the long history of management efforts and accelerating reef degradation, the United States Congress stepped in. In 1988, under the looming threat of oil drilling and following a series of damaging ship groundings, a series of feasibility studies were conducted to assess whether existing marine sanctuaries could be expanded (U.S. Department of Commerce, 2007). These studies spotlighted the uncertain trajectory of the Florida Reef Tract and culminated in bipartisan support for the formation of the FKNMS on November 16th, 1990 (U.S. Department of Commerce, 2007).

Since its creation, the FKNMS has remained at the forefront of conservation in Southeast Florida. Administered at the federal level by the National Oceanic and Atmospheric Administration (NOAA) and co-managed by the Florida Department of Environmental Protection (DEP) at the state level, this 2,800 square nautical mile sanctuary (Figure 10,

Appendix B) restricts activities such as drilling, shipping, anchoring, and poaching, which could harm vulnerable ecosystems (U.S. Department of Commerce, 2007). Currently, there are five types of marine zones within the sanctuary that support various types of resource use and protections for habitat and wildlife. However, while sanctuary-wide regulations exist, such as limitations on human-wildlife interactions with endangered species, marine zoning with stricter regulations (i.e., complete restrictions on fishing, termed "no-take zones") only account for a small fraction of the Sanctuary's total area. (Office of National Marine Sanctuaries, 2019)[7].

The Sanctuary's catalyst, the Florida Keys National Marine Sanctuary and Protection Act, also required a comprehensive management plan, which was put into place in 1997 and revised in 2007 (Baker, 1999; Gregg, 2013). As of 2021, the Comprehensive Management Plan is undergoing a third revision based on the outcomes of a Draft Environmental Impact Statement known as the Florida Keys National Marine Sanctuary's Restoration Blueprint.[8] As stipulated by Congress, the current iteration of the Comprehensive Management Plan aims to reduce environmental degradation in critical areas by reducing exploitation, protecting vulnerable species, and minimizing conflicts among sanctuary visitors through an evolving process of marine zoning (Office of National Marine Sanctuaries, 2019). The plans are continually monitored and reviewed through federal and state agencies in conjunction with the Sanctuary Advisory Council. The Council is made up of local representatives and stakeholders from the Monroe County government, cooperating management agencies, conservation groups, universities, and other organizations with vested interests in the health of the Florida Reef Tract (Sleasman, 2009). Based on the input of the Sanctuary Advisory Council, the regulations set forth by the FKNMS are strictly enforced by the Florida Fish and Wildlife Conservation Commission (FWC) in partnership with the NOAA Office of Law Enforcement and the U.S. Coast Guard (U.S. Department of Commerce, 2007).

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[7] A complete overview and interactive map of the Sanctuary's zones can be found here: *"Exploring Sanctuary Zones and Regulations"* https://arcg.is/0qGSe0

[8] More information about the Restoration Blueprint can be found here: *"Florida Keys National Marine Sanctuary Restoration Blueprint"* https://floridakeys.noaa.gov/blueprint/

Initially, the FKNMS Management Plan was largely non-regulatory, focusing instead on public education, channel marking, environmental surveying, and the installation of mooring buoys to prevent anchor damage. However, through time, it has developed to include many new management areas, sanctuary preservation areas, ecological reserves, and regulations that help to manage water quality, wildlife, and social-ecological interactions (Gershman et al., 2012; Office of National Marine Sanctuaries, 2019). For example, since its implementation in 1997, NOAA has expanded the sanctuary to include the Dry Tortugas Ecological Reserve, added no-discharge regulations in state and federal waters to improve water quality, and implemented numerous monitoring programs to track coral bleaching, coral disease, and other indicators of ecosystem health (Office of National Marine Sanctuaries, 2019).

As previously mentioned, the unique ecological opportunities afforded by the Florida Reef Tract make it a global hotspot of marine tourism, recreation, and industry (NOAA Coral Reef Conservation Program, 2020). Much of Florida's economy is closely linked to this valuable natural resource, which generates billions of dollars annually in goods and services (Wynveen et al., 2013). In 2015 the Florida Keys National Marine Sanctuary contributed 38,111 jobs and $2.57 billion to Florida's economy (TBD Economics, 2019).

(3.3) The Southeast Florida Coral Reef Initiative

While about two-thirds of Florida's 360-mile-long coral reef is protected by The Florida Keys National Marine Sanctuary and Biscayne National Park (Figure 7, Appendix B), approximately one-third extends northward from Miami-Dade County to Martin County (Figure 7, Appendix B). However, this area has historically lacked a comprehensive management plan, and until recently, very little was known about the extent and status of this portion of the Florida Reef Tract (Gregg, 2013). Thanks to the efforts of a relatively new conservation organization known as the Southeast Florida Coral Reef Initiative (SEFCRI), as of February 2018, this region is now known as the Kristin Jacobs Coral Reef Coral Ecosystem Conservation Area (ECA).

Additionally, through SEFCRI, new management strategies are in continuous development (Florida Department of Environmental Protection, n.d.-a, n.d.-b).

Officially formed in 2003, SEFCRI bridges a gap between formal governmental organizations, like the Florida Keys National Marine Sanctuary and other non-governmental partners interested in preserving the immense value of the Florida Reef Tract. Since its creation, more than 70 partners have implemented over 140 projects through SEFCRI, including geospatial analysis of reef distribution, reef-fish biomass assessments, water quality sampling, invertebrate species surveys, and socioeconomic studies to better inform decision-makers and stakeholders about the state of the northern reaches of the Florida Reef Tract (Florida Department of Environmental Protection, 2004; Gregg, 2013).

SEFCRI is a product of the United States Coral Reef Task Force, which was established in 1998 to "protect and preserve the biodiversity, health, heritage, and socioeconomic values of [U.S.] reefs and the marine environment" (Florida Department of Environmental Protection, 2004). The Coral Reef Task Force consists of representatives from U.S. states, commonwealths, and territories home to coral reef ecosystems. In 2002 the Task Force called for each of its seven member-states to create "Local Action Strategies", which targeted key threats to coral reef ecosystems. These threats included overfishing, sources of land-based pollution, recreational overuse and misuse, lack of public awareness, climate change, coral bleaching, and coral disease (Florida Department of Environmental Protection, 2004). While the task force has implemented many local action strategies to combat coral reef decline in places like Hawaii, American Samoa, and Puerto Rico, the immense scale and value of the Florida Reef Tract necessitated the formation of SEFCRI to facilitate local conservation and management operations outside of the Florida Keys National Marine Sanctuary (Florida Department of Environmental Protection, 2004).

Since its creation, SEFCRI has been coordinated by the Florida Department of Environmental Protection's Coral Reef Conservation Program. At its core, SEFCRI is a

collaborative network of partners that focuses on Miami-Dade County, Broward County, Palm Beach County, and Martin County (Figure 7. Appendix B). As previously noted, these areas historically lacked the focused environmental protection and management that the reefs adjacent to Monroe County received through the FKNMS' administration. In response, the SEFCRI team was formed under the guidance of the U.S. Coral Reef Task Force, the Florida Department of Environmental Protection, and the Florida Fish and Wildlife Conservation Commission (Florida Department of Environmental Protection, 2004). The SEFCRI team consists of a wide range of government agencies, non-governmental organizations, universities, and private partners; all focused on protecting southeast Florida's coral reefs while maximizing cooperation and transparency among all participants (Southeast Florida Coral Reef Initiative, 2019).

The SEFCRI team operates using focus groups that tackle the five primary components of their Local Action Strategy, which is similar to the coordinated management plan of the FKNMS. These focus areas include: (1) Awareness and Appreciation,[9] (2) Fishing, Diving, and Other Uses,[10] (3) Land-Based Sources of Pollution,[11] (4) Maritime Industry and Coastal Construction Impacts,[12] and (5) Reef Resilience (Kerrigan, 2017; Reisewitz & Harper, 2013).[13] Each focus group is led by representatives, termed "Navigators," who are responsible for

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[9] "The Awareness and Appreciation Focus Area was formed to address coral reef degradation that can be attributed to a lack of knowledge or understanding by the general public, which is a recognized threat to coral reefs by the U.S. Coral Reef Task Force." (FDEP., n.d.-b)

[10] "The Fishing, Diving, and Other Uses Focus Area was formed to address impacts caused by activities such as fishing, diving and boating. Actions associated with these activities often result in unseen and unintended impacts that alter reef ecosystems." (FDEP., n.d.-b)

[11] "The Land-Based Sources of Pollution Focus Area was formed to address impacts to corals resulting from both point and non-point land-based sources of pollution. Point and non-point sources of pollution result in unintentional but very real stresses on coral reef ecosystem health." (FDEP., n.d.-b)

[12] "The Maritime Industry and Coastal Construction Impacts Focus Area was formed to address coastal construction and maritime industry activities that have the potential of impacting our coastal habitats and coral reefs. Activities such as vessel anchoring and groundings, infrastructure installation (e.g., cables, pipelines and outfalls), beach nourishment, and dredge and fill operations in and around coral reefs and coastal habitats can adversely affect these sensitive ecosystems." (FDEP., n.d.-b)

[13] "The Reef Resilience Focus Area addresses two main issues: (1) lack of information needed to manage for resilience and (2) public awareness of the importance of reef resilience. Part of planning for resilience includes understanding the spatial variation of local and global stressors, identifying which actions may be effective against those stressors, and deciding where to implement priority actions to restore ecosystem services and maximize resilience potential." (FDEP., n.d.-b)

"defining and revising goals, objectives, actions, priority setting, budget development, building implementation teams, and tracking progress" (Florida Department of Environmental Protection, 2004). These Navigators may be agency-affiliated (where they represent their agency within SEFCRI and vice versa), or they may also be non-agency Navigators who represent local stakeholder views and exist as primary points of contact for their constituents. In this way, SEFCRI creates a network of participants, all working towards common goals (Florida Department of Environmental Protection, 2004). Like the Florida Keys National Marine Sanctuary, the Florida Department of Environmental Protection's management decisions rely heavily on a transparent process that encourages stakeholder inclusion. An advisory board (the Technical Advisory Committee) made up of the leading research scientists in various fields related to reef management assists the SEFCRI team in identifying and implementing priority actions to reduce key threats to coral reef resources in the SEFCRI region. The SEFCRI region is also known as the Kristin Jacobs Coral Reef Ecosystem Conservation Area (Florida Department of Environmental Protection, n.d.-d).

To select priority actions within each of the five focus areas, SEFCRI has developed guidelines that assess any project's scope, feasibility, relevance, requirements, and ethics (Florida Department of Environmental Protection, 2004). The prioritization process helps ensure that any projects undertaken in new iterations of the Local Action Strategy are best-fit for the issues at hand. For example, in 2017, SEFCRI produced a Reef Resilience project report co-funded by NOAA's Coral Reef Conservation Program, the Florida Department of Environmental Protection, and The Nature Conservancy's Florida office, which showed that the northern Florida Reef Tract was extremely vulnerable to the effects of climate change and suggested management actions that could address critical risk factors (Maynard et al., 2017). Typically, each project aims to be completed within a three-year timeframe. However, the current iteration of the Local Action Strategy, also released in 2017, is still underway (Florida Department of Environmental Protection, 2004; Kerrigan, 2017). Additionally, there is no proposed end to the SEFCRI mission. Presumably, operations will continue long-term, given that funding is appropriated and the ecological situation necessitates further action.

(3.4) Institutions

Before moving on, it is important to define how I use the term "institution" in the context of this research, especially when discussing the FKNMS and SEFCRI. While institutions can describe societal organizations founded to address specific issues, I use them to describe the rules that govern the behavior of actors (Pahl-Wostl, 2015). In my research, when I reference the FKNMS and SEFCRI, I am referring collectively to the actors such as public stakeholders, governmental agencies, and non-governmental organizations that operate under different types of institutions, collaborate towards common goals, and enable the FKNMS and SEFCRI to function. Organizations like SEFCRI and the FKNMS include elements of what the academic literature calls "polycentric" or "multi-level" governance, defined as organizations with many centers of decision-making that are formally independent of one another, have jurisdictional units of different sizes and spatial extents, and operate as self-organized wholes (Ostrom, 2010). Depending on the context, polycentric governance systems rely on different sets of internalized rules (i.e., institutions).

There are two types of institutions. First, formal institutions operate on state-mandated regulations that are inexorably linked to the official channels of governmental bureaucracies and are legally enforced by state-actors (Pahl-Wostl, 2009). State-actors are governmental bodies that adhere to strict formal institutions (i.e., laws and regulations).[14] Second, informal institutions rely heavily on cultural norms, evident in public discourse, that are not explicitly written down. Informal institutions typically include non-state actors but may incorporate state-actors as well (Pahl-Wostl, 2009). Non-state actors are individuals, private companies, and civil society organizations, which often play critical supporting roles in decision-making but lack regulatory authority (Carlisle & Gruby, 2019).[15] When applying these concepts to this research, the FKNMS

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[14] *Example*: The Florida Fish and Wildlife Conservation Commission (a governmental agency), is a state actor, which is largely responsible for enforcing the regulations stipulated by the FKNMS.
[15] *Example*: The Nature Conservancy (a non-governmental organization) is a non-state actor, which is partnered with SEFCRI and helps to inform management decisions made by the Florida Department of Environmental Protection.

consists of state-actors that rely heavily on formal institutions. In contrast, SEFCRI includes state *and* non-state actors, which rely on formal *and* informal institutions. Therefore, each organization approaches management differently.

When multiple actors (state, non-state, or both) interact, they form actor networks. The roles of these actor networks and the way they operate can be categorized into three "modes of governance" (Pahl-Wostl, 2009). These modes of governance include bureaucratic hierarchies (formal institutions of government, where state actors make decisions), networks (state and non-state actors collaborate to make decisions), and markets (private sector actors participate heavily and influence the decisions of both state and non-state actors). These modes may or may not overlap, meaning that actor-networks can fall into multiple categories simultaneously (Pahl-Wostl, 2009). For example, the FKNMS is primarily a bureaucratic hierarchy, whereas SEFCRI is mainly an actor network. Modes of governance are essential to understand because, in conjunction with institutions, they can help explain different decision-making processes within separate organizations.

As one can see, polycentric governance is not restricted to formal governmental bodies. Instead, it is characterized by the roles of *both* state (e.g., federal agencies) and non-state (e.g., non-profit organizations) and the networks they form (Carlisle & Gruby, 2019). These roles have evolved over time, decreasing reliance on state actors for environmental conservation and thus increasing dependence on non-state actors to help supplement management (Roberts & Devine, 2003). The rising prominence of non-state actors in conservation governance means that private entities or volunteers increasingly help to inform and implement governmental policies, programs, and services. As a result, actor-networks form, which may not have been previously associated (Roberts & Devine, 2003); case in point, SEFCRI, where a broad range of state and non-state actors have come together to protect the upper portion of the Florida Reef Tract.

Although the increasing participation of NGOs and volunteers can be positive, it can also be detrimental. Depending upon their vested interests, stakeholder attitudes may be incredibly

diverse and even contentious. So, although these new actor networks can facilitate progress through cooperation, they may also increase conflicting attitudes that can impede progress (De Groot et al., 2002; Dunning, 2018). Keeping this information in mind, I aim to incorporate the concepts of institutions, modes of governance, and the roles of actor-networks to help explain the dynamics of both the FKNMS and SEFCRI and compare the approaches of each to managing the Florida Reef Tract.

4. Theoretical Framework

The Florida Reef Tract is likely to be distinguished as a *novel ecosystem*. Recent shifts in species distribution, ecosystem services, and ecosystem functionality have fundamentally altered how decision-makers must approach management across spatial and temporal scales (Rogers et al., 2015). Luckily, the United States possesses the capacity, resources, and infrastructure necessary to implement conservation management strategies in Florida that may serve as a learning model applicable to reefs worldwide. Two questions emerge:

1. How does coral reef management vary over the different spatial extents and organizational structures of the FKNMS and SEFCRI?

2. How do these organizations vary in incorporating important aspects of novel ecosystem management?

(4.1) Concepts for Managing a Novel Ecosystem

Clement and Standish (2018) present five important concepts or "sticking points" for novel ecosystem governance. These concepts are: 1) *Administrative Competence* 2) *Buffering,* 3) *Culture and Norms,* 4) *Framing* (what I refer to as "*Issue Framing*")*;* and, 5) *Power and Authority*. The authors suggest that under novel ecosystem circumstances, conservation governance needs to be tailored to best fit the social and ecological needs of an ecosystem and the people that interact with it. Below, I briefly define each concept, provide additional literature and examples, and explain how they relate to this research using my own interpretations.

Administrative Competence asks whether conservation practitioners have the basic skills, knowledge, and resources required to manage a novel ecosystem effectively. Administrative competence assesses whether agencies or actors therein can effectively do their jobs. In addition to having the right staff and skills to complete the mission, this concept also addresses if organizations adequately allocate resources and effectively problem solve when necessary

(Clement et al., 2016). Administrative Competence as an element of adaptive governance, especially in the context of coral reef management and novel ecosystems, is ubiquitous (Anthony et al., 2020; Clement et al., 2016; Morrison et al., 2020; Rijke et al., 2012). Without competent managers who are able to assess the feasibility of projects and objectives using sound science, the success of conservation projects and the ability to adapt under new evidence and circumstances may be at risk. Without a doubt, the ability of agencies, organizations, and managers to handle problems that are complex, unpredictable, and open-ended often calls for extensive management capabilities (Head & Alford, 2015).

Buffering refers to the ability of managers to cope with uncertainty through directing adequate responses to the right stressors while managing social and ecological influences on an ecosystem and the organizations tasked with conservation (Clement & Standish, 2018). Buffering requires redundancy, which underpins resilience. Redundancy could take the form of a range of possible responses, where institutions implement several different responses to a disturbance, thereby reducing uncertainty via repetition. Buffering could also relate to organizational Buffering, such as strategies to deal with political hurdles that influence conservation outcomes (Clement et al., 2016). Managing uncertainty is an integral part of adaptive management in novel ecosystems because uncertainty and unpredictability are inherent components of complex social-ecological systems (Allen & Gunderson, 2011; Hobbs et al., 2013). Ultimately, while the literature still lacks a consensus on how to address the transformative changes of novel ecosystems, given the rapid development of marine and terrestrial novel ecosystems, implementing Buffering may help further our understanding of effective management approaches in the near future (Clement & Standish, 2018).

Culture and Norms must be considered part of novel ecosystem governance because they help determine what are considered acceptable actions in conservation and restoration (Clement & Standish, 2018). While many marine ecosystems have immense cultural value, its importance can be neglected in marine conservation (Gee et al., 2017). Furthermore, the many distinctions that can be made about why and how people value an ecosystem (e.g., economic value versus

cultural heritage) help managers carefully consider attitudes, beliefs, and behaviors when developing management plans (Ives & Kendal, 2014). Social-ecological systems like the Florida Reef Tract can be very complex and multiple factors can influence their different cultural dynamics. For example, cultural dimensions may include (1) *meanings, values, and identities* which constitute a 'way of life' and change over time and through space; (2) *local ecological knowledge and practice*, such as a cumulative knowledge of the environment, including its social and spatial conditions; (3) *livelihood dynamics*, such as commercial or noncommercial resource harvesting, job satisfaction, quality of life, and occupational identity; (4) *governance and access*, including mechanisms of control which may be tied to philosophies or relationships and complicated by political issues or power dynamics; and (5) *biological-cultural interactions* such as cultural keystone species that help to shape cultural identities (Poe et al., 2014). Clement and Standish (2018) add that enduring preferences or ideas about what constitutes conservation and restoration, such as using perceived historical baselines to set targets and define success, can be significant barriers to accepting novel management strategies. They go on to highlight that "fostering new norms" presents a unique challenge because the public may devalue novel ecosystems, changing their perception of what is worth protecting (Clement & Standish, 2018).

Issue Framing captures how biodiversity and conservation are conceptualized at a given place and time; it determines the rationale for conservation, the actors involved (i.e., stakeholders), and what solutions/actions are deemed necessary (Clement & Standish, 2018). Issue Framing involves identifying a phenomenon (e.g., coral bleaching), evaluating it (e.g., asking, "why is coral bleaching a problem?"), identifying possible causes (e.g., greenhouse gas emissions), and eventually offering solutions (e.g., implementing early warning systems, such as BleachWatch) (Lele, 2018).[16] Framing also has a political component—the ways in which environmental issues are framed can impact public support for conservation initiatives and influence attitudes and behaviors related to the environment (Jacobson et al., 2019; Kusmanoff et al., 2020). For example, simply framing coral reef degradation as only a biological problem,

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[16] The Florida Department of Environmental Protection's Southeast Florida Action Network (SEAFAN) BleachWatch Program aims to detect and monitor coral bleaching events and improve scientific understanding (Florida Department of Environmental Protection, n.d.-c).

rather than a biological problem that is closely tied to social and economic systems, may fail to generate appropriate interventions across multiple scales (Morrison et al., 2020). Indeed, reframing the way we approach our perceptions and understandings of novel ecosystems enables more conventional management strategies to be implemented, which move away from historical baselines, incorporate cultural values, and build adaptive capacity among institutions (Clement & Standish, 2018).

Finally, *Power and Authority* applies directly to conservation governance and its ability to either inhibit or catalyze environmental change. It considers institutional dynamics, such as power structures and policymaking, which play vital roles in how decisions are made, enforced, and justified.

> "Governance establishes institutions and policies; empowers individuals and organizations to act; and allocates roles, responsibilities, and authority. Authority confers formal power to act and can be codified in law, but it may also be more informal and arise from differing levels of political influence, money, or other resources" (Clement & Standish, 2018).

Many of these elements of Power and Authority can be considered when assessing the quality of governance systems and may also include public perceptions like perceived legitimacy and trust in government (Lockwood et al., 2012). Further research reveals that trust and perceived legitimacy are integral parts of conservation governance (Barrow & Murphree, 2001); that they improve public compliance with conservation policies, and that Power and Authority should be considered when assessing the quality of environmental governance (Borrini-Feyerabend & Hill, 2015; Thaker et al., 2019; Young et al. 2016). My research operationalizes Power and Authority as clearly defined roles and responsibilities within FKNMS and SEFCRI and stakeholder perceptions of governance therein.

(4.2) Institutional Learning

To supplement the novel ecosystems literature and to help explore the institutional dynamics that may contribute to the nature of the FKNMS and SEFCRI, I also incorporate

Pahl-Wostl's Framework for Adaptive Governance (2009). This framework utilizes an organizational theory of learning developed by Argyris & Schön (1997) to explore how institutions, non-state actors, and modes of governance evolve from learning and contribute to more effective conservation governance strategies via adaptive governance. The framework employs the concepts of single, double, and triple-loop learning to classify magnitudes of change. Single-loop learning is found in small, day-to-day actions where changes are incremental improvements towards meeting management goals. Double-loop learning is present when problems are reflected on and guiding assumptions about how goals can be achieved are questioned. Double-loop learning may lead to new approaches to resource management. Triple-loop learning refers to the complete overhaul of regulatory frameworks or fundamental changes in values or ideologies. Triple-loop learning comes with the recognition that current systems are ineffective at achieving resource management objectives. Therefore, triple loop learning results in new actors joining networks, the changing of power structures, and the introduction of new regulatory frameworks through adaptive governance (Pahl-Wostl, 2009). Additionally, actor-networks support learning by providing access to new information from many different sources. However, multiple actors may interpret that information differently, resulting in conflict (Pahl-Wostl, 2009).

Improving the effectiveness of existing conservation governance by identifying the *best* management strategies for novel ecosystems may alleviate conflict, encourage triple-loop learning, and unite actor networks. For this reason, I include the presence of single, double, and/or triple-loop learning in the design of this study.

5. Methods

This study draws on concepts from the novel ecosystems, social-ecological systems, and adaptive governance literature to help frame the current and future management of the Florida Reef Tract. I employed two conceptual frameworks to compare the approaches of the Florida Keys National Marine Sanctuary and the Southeast Florida Coral Reef Initiative . I assessed how each organization incorporated the five important concepts, defined as "sticking points," when managing a novel ecosystem. This project utilizes a comparative case study design and mixed-methods as described by Yin (2017) and Creswell (2014) to answer my stated research questions:

1. How does coral reef management vary over the different spatial extents and organizational structures of the FKNMS and SEFCRI?

2. How do these organizations vary in incorporating important aspects of novel ecosystem management?

Data included meeting minutes (i.e., transcripts recorded during advisory council/committee meetings), news documents (including newspaper articles, press releases, newspaper blogs, and news transcripts), and remote interviews with representatives and participating stakeholders from the Southeast Florida Coral Reef Initiative and the Florida Keys National Marine Sanctuary. Using the appearance of mass coral bleaching events along the Florida Reef Tract as a temporal threshold, denoting a shift from historical to contemporary ecosystem functionality and management needs, I compiled a total of 1,122 individual data points ($n = 1,122$) from both organizations, FKNMS ($n = 541$) and SEFCRI ($n = 581$), throughout the summer of 2021.

News document data were collected from the NexisUni database, which initially revealed over 10,000 results when searching "Florida Keys National Marine Sanctuary" or "Southeast Florida Coral Reef Initiative." However, many of these results were irrelevant within the scope

of this study; therefore, modifiers were added to narrow the search results. First, for the Florida Keys National Marine Sanctuary, 179 documents were isolated using the "News" filter and the Boolean search "Florida Keys National Marine Sanctuary" AND "management." These results were then filtered using the category "Newspapers" and the date range "1996 - present." The reason I focused on newspaper articles was to make the amount of FKNMS news data more manageable. Additionally, 1996 was selected as a starting point because the first mass bleaching event to occur in Florida after the creation of the FKNMS was in 1997. Of the 179 results, 79 were deemed relevant to this study, and 100 were excluded. The results were manually sorted to determine their relevance to this research. Any articles that were outside the scope of this study were therefore excluded. For example, one article focused on new funding for habitat restoration in the Everglades National Park and mentioned both the Florida Keys National Marine Sanctuary and "management" in that context. However, this had no direct relevance to the management of the Florida Reef Tract (Wadlow, 2010).

Second, for the Southeast Florida Coral Reef Initiative, 99 results were isolated using the "News" filter and the Boolean search "Southeast Florida Coral Reef Initiative" OR "SEFCRI" OR "Ecosystem Conservation Area." Because SEFCRI is a newer organization (established in 2003), there was no need to limit the date range. However, the more recent establishment of this organization also meant that there were fewer newspaper articles available. Therefore, I also included more comprehensive sources of news such as the newswires, press releases, newspaper blogs, and news transcripts previously mentioned. For this reason, the decision was made to manually sort all 99 initial results for relevance to this project rather than narrow the results any further using modifiers or filters. Of the initial 99 results, 20 were deemed relevant, and 79 were excluded. These decisions were based on similar criteria used for the FKNMS results (i.e., relevance to the management of the Florida Reef Tract). For example, one recent newspaper article announced the renaming of SEFCRI's "Coral Reef Ecosystem Conservation Area" to the "Kristin Jacobs Coral Reef Ecosystem Conservation Area." However, this information was deemed irrelevant to SEFCRI's management of the Florida Reef Tract (Nicol, 2021).

Meeting Minutes data from each organization's advisory meetings were collected from two sources. First, the meeting minutes for the Florida Keys National Marine Sanctuary's Sanctuary Advisory Council were accessed via the archives on their website (Florida Keys National Marine Sanctuary, n.d.-a). Second, the meeting minutes for the Southeast Florida Coral Reef Initiative's Technical Advisory Committee were accessed via the archives on the Florida Department of Environmental Protection's website (Florida Department of Environmental Protection, 2022). I chose meeting minutes from the Sanctuary Advisory Council and Technical Advisory Committee because these groups provided a mix of representatives from each organization and stakeholders from different communities associated with the Florida Reef Tract. While the Sanctuary Advisory Council and Technical Advisory Committee lack direct rule-making authority, they each play critical roles within the decision-making processes of each organization and are therefore highly representative (Florida Department of Environmental Protection, n.d.-d; Florida Keys National Marine Sanctuary, n.d.-b). To maximize comparability between the two organizations, I chose only to select meeting minutes available from each organization at similar points in time (Spring/Summer, 2015-2020). This method resulted in a total of 12 meeting transcripts, one transcript per organization per year.

Remote interview data were collected from transcripts of semi-structured interviews conducted throughout the summer field season (May 5 – August 1) of 2021. Participants were selected based on their status as important stakeholders, decision-makers, and representatives from the SEFCRI Team Charter (9 participants) and the FKNMS Advisory Council (9 participants). The semi-structured interview methodology used in this research project was approved by the Office of Human Research at Auburn University (Protocol # 21-088 EP 2103). Written consent was obtained from each participant before each remote interview. The consent form included 1) a brief introduction to the study; 2) information related to how the data would be used; 3) an explanation of any risk involved to the participants; 4) all steps taken to ensure risk was minimized; and 5) information about the participant's right to withdraw from the study at any point in time voluntarily. To help ensure honest and representative answers, participants' personal information remained completely confidential at all times. Interviews were conducted

virtually using Zoom™ software. At the beginning of each interview, participants were asked permission to record audio and video logs which the Zoom software automatically transcribed. These transcripts were then double-checked by hand to ensure accuracy. If the participant agreed, Zoom recordings and transcripts were saved to a secure Auburn University cloud account. If the participant preferred not to be recorded, detailed notes were taken by hand for the duration of the interview and stored securely.

After all data sources had been compiled, I began a process of deductive qualitative coding using the five concepts for managing novel ecosystems identified by Clement and Standish (2018) and loop-learning as defined in Pahl-Wostl's Framework for Adaptive Governance (2009). Results were reviewed and coded based on their content related to 1) *Issue Framing*, with a focus on reframing the problem and adopting novel solutions; 2) *Culture and Norms* with an emphasis on stakeholder inclusion and cultural values; 3) *Power and Authority*, including information on clearly defined roles/responsibilities and perceived legitimacy; 4) *Administrative Competence*, assessing whether practitioners are effectively doing their jobs; and (5) *Buffering*, which assessed preparedness related to sources of organizational and ecological uncertainty. Additionally, each data point was coded for the presence or absence of *single*, *double*, and *triple-loop* learning to help gauge institutional progress towards effective adaptive governance. Finally, the content of each data point was assessed as either *negative* or *positive*, denoting the presence or absence of criticism about the organization.

The document analysis process for this study initially began with each document representing one data point which included multiple perspectives from different stakeholders. For example, some news documents, such as newspaper articles, included four or five competing perspectives related to the Administrative Competence of either organization about various concerns. Additionally, these perspectives were often framed in a positive or negative light. Because of these factors, the aggregate data lacked some specificity, which threatened to attenuate my results. To remedy this problem, each document was treated as a single source for multiple data points, each representing different perspectives of stakeholders and

decision-makers. Afterward, this information was analyzed and leveraged to compare the two institutions and their approaches to managing the Florida Reef Tract. Below I outline my coding methodology in greater detail.

For this research, I utilized a deductive content analysis approach that used elements of concept coding as described by Saldaña (2016). Deductive content analysis is an analytical method that can test existing theoretical frameworks, categories, or concepts in a new context and with new data (Kyngäs & Kaakinen, 2020). In other words, deductive content analysis applies prior theoretical knowledge as the starting point, in this case, the five concepts for managing novel ecosystems, and allows those concepts to act as a lens through which to examine new cases. Additionally, I incorporated concept coding as a way to allow for some flexibility and generality. Concept coding also allows specific statements to be grouped into general categories (i.e., the five important concepts for managing novel ecosystems) via their related elements (Saldaña, 2016). In this case I refer to the individual elements of each concept as *subcomponents*. For example, within *Administrative Competence,* many different kinds of statements can be categorized based on their content. Two such subcomponents were *Feasibility* and *Technical Know-How* (Table 2.1). These subcomponents were originally derived from the definition of Administrative Competence provided by Clement and Standish (2018). However, as needed, additional subcomponents were created based on their relevance to themes in the data. For example, *Perceived Legitimacy* was added as a subcomponent within *Power and Authority* based on my empirical observations that there existed public contention around the establishment of regulatory bodies like the FKNMS.

Before any data sources were coded, several pieces of information were recorded: the source URL, the date of the document, the date of entry, the specific quote, the speaker's name, the speaker's organizational affiliation, and their role (if any). Then each quote was assessed and coded based on its relevance to each of the five concepts for adaptive governance and its applicability to single, double, or triple loop learning. At the same time, the phrasing and content of each quote were assessed as either "positive" or "negative," and the results were recorded.

This was done to identify where the highest levels of criticism exist for each organization, highlighting areas that could be considered for future improvement via adaptive governance and management practices. Lastly, a justification was added for each code, describing why subcomponents were identified. This was done in order to provide additional context and specificity. This process was repeated for every entry in my datasheet. More detailed descriptions and examples are given in my findings section.

For my quantitative analysis, I used two-tailed difference of proportions t-tests to identify significant differences in the proportions of each concept as well as differences in the proportions of single, double, and triple-loop learning. While my purposeful sampling was not completely random or exhaustive, the diversity in my data sources, including news media, advisory meetings, and interviews, ensured a large and representative sample of the stakeholders and practitioners involved with both the FKNMS ($n = 541$) and SEFCRI ($n = 581$). Once the significant differences had been calculated for each concept (Table 4) and each level of learning (Table 5), I was able to explore each theme in-depth and couple my qualitative and quantitative data to accurately describe the differences between each organization.

Data quality assurance and quality control (sometimes referred to as QA/QC) were conducted throughout the data collection phase of this project. QA/QC includes data validation, cleaning, and consistent checking, which ensures data integrity (Bowser et al., 2020). To do this, I employed a process of intercoder reliability, where an additional independent coder double-checks the work of the initial coder to identify any irregularities and safeguard consistency within the dataset (Lavrakas, 2008). In addition, I used triangulation, where different sources of data (i.e., news, meeting minutes, and interviews) were combined with quantitative and qualitative analysis (mixed methods) to improve the validity of my research and help control sources of potential bias (Creswell & Miller, 2000).

6. Findings

Using the five concepts (i.e., sticking points) to managing novel ecosystems and their specific subcomponents, which were identified by Clement and Standish (2018) and modified for this research, I employed a process of deductive content analysis and supplemental two-tailed difference of proportion t-tests to first sort and then examine the collected data. Several patterns emerged in my data during this process, which I unpack later in this section. Each concept that I coded for is summarized in Table 1. The subcomponents of each concept (i.e., the specific elements I used to identify the presence or absence of a concept) are individually described in Table 2. These subcomponents were initially derived from the literature (see: Clement & Standish, 2018), but some, such as *Perceived Legitimacy*, were added ad hoc as new themes became apparent, which required new descriptors. In addition to descriptions of each subcomponent, Table 2 includes an example for each. The subcomponents are categorized according to their relevance to each concept—*Administrative Competence, Buffering, Culture and Norms, Issue Framing, and Power and Authority*. These tables (1 and 2) are intended to be used as references throughout my findings section. For example, when I mention Administrative Competence, I am referencing any information which described instances of the FKNMS or SEFCRI using one of the six subcomponents of Administrative Competence (e.g., *Structured Decision Making* or *Due Diligence*) to effectively manage and conserve their portion of the Florida Reef Tract (Table 1). If the idea of a subcomponent like Structured Decision Making needs more clarity, refer to Table 2, where a definition of the subcomponent is provided as well as an example from the text.

Table 1. Concepts for adaptive governance in novel marine ecosystems, their summaries, and subcomponents.

Concepts	Concept Summary	Subcomponents
Administrative Competence	Information about whether an institution is effectively conserving the ecosystem	Structured Decision Making; Due Diligence; Effective Resource Management; Feasibility; Technical Know-How; Cooperation
Buffering	Information about whether an institution is adequately prepared for the future	Preparedness; Managing Uncertainty; Sufficient Data Collection; Directional/Proportional Responses

Culture and Norms	Information about whether an institution includes stakeholders, engages the public, and encourages shared understanding	Stakeholder Inclusion; Public Outreach; Cultural Heritage; Homogenization of Values
Issue Framing	Information about whether an institution adequately considers anthropogenic impacts and novel solutions	New/Changing Objectives; Novel Solutions; New Species Interactions; New Ecosystem Functionality; New Understanding; Anthropogenic Effects
Power and Authority	Information about whether an institution is well organized, capable, respected, and willing to consider changes	Clearly Defined Roles & Responsibilities; Regulatory Enforcement; Compliance; Institutional Changes; Procedural Changes; Perceived Legitimacy

Table 2. Concepts for adaptive governance in novel ecosystems, their subcomponents, descriptions, and examples.

Administrative Competence (2.1)		
Subcomponents	**Subcomponent Description**	**Example**
Structured Decision Making	Any mention of decision-making processes that utilized elements such as management objectives, options, and predictions to make informed decisions	"We had a very, very formal process, I mean they brought in a professional coordinator to run the meetings and everybody proposed projects. We had formal voting, we refined the projects, we combined some, we tossed some out, it was very, very formalized and I thought very well done as a matter of fact." - NGO Representative, Technical Advisory Committee (SEFCRI)
Due Diligence	Any mention of extra steps taken to ensure that facts, details, or concerns were being adequately considered	"We seek to restore corals and restore habitat by transplanting corals, being careful not to lose diversity in one area or create lack of diversity in a new area, because I don't think we know enough about how everything reacts with each other." - Representative, Technical Advisory Committee (SEFCRI)
Effective Resource Management	Any mention of management actions, policies, regulations, or programs that were directly beneficial to conservation	"I know that [the FKNMS is] addressing the coral loss through Mission Iconic Reefs, I think that program to me seems like it's a really well funded and well-implemented plan and they've got a lot of different groups working on out-planting corals and stuff and I think that that's probably the most successful thing I've seen in relation to combating climate change." - Representative, Sanctuary Advisory Council (FKNMS)

Feasibility	Any mention of considerations about the practicality of management actions	"I think that [the FKNMS] takes everything into account, but some of the stuff is just so off the wall that [...] they can't act on everything. So, I think that they do a very good job of filtering the comments that they do get and picking out the diamonds in the rough." - Researcher (FKNMS)
Technical Know-How	Any mention of the specific knowledge, skills, and expertise that managers possesed	"I've been a Council member [for] 20 - 23 years. But, the reason that I joined the Council was to bring knowledge about how Everglades restoration is going to impact the coral reef." - Representative, Sanctuary Advisory Council (FKNMS)
Cooperation	Any mention of people, agencies, or institutional elements working together towards common goals	"Seeing all three of those organizations that have historically been competitors, and they're still competitors for funding, but watching the three of them work together side by side in a location, it's hard not to be optimistic when you see that." - Researcher (FKNMS)

Buffering (2.2)		
Subcomponents	**Subcomponent Description**	**Example**
Preparedness	Any mention of actions taken to ensure that managers have the tools necessary for data collection	"Now we're actually establishing our own monitoring network. Because we've discovered that salinity is affecting coral reefs much further than the Saint Lucie Inlet." - Representative, Technical Advisory Committee (SEFCRI)
Managing Uncertainty	Any mention of the tools, programs, or procedures which helped managers defend against unforeseen future disturbance(s)	"We've learned a lot about restoration, we've harvested tissue to ensure genetic diversity and healthy populations, so that's my hope and outlook on the future of the reef tract but getting it into a position where it can be restored." - Representative, Technical Advisory Committee (SEFCRI)
Sufficient Data Collection	Any mention of robust data collection which helped to clarify the status of the ecosystem or provide relevant predictions for management	"Florida Department of Environmental Protection's (DEP) main concerns are impacts to resources and water quality. A benthic survey of the area is needed to make sure no corals or seagrass will be impacted. The structure being placed needs to be clean and can't violate water quality standards." - Representative, DEP (SEFCRI)
Directional/ Proportional Responses	Any mention of responses that matched the scale of a problem and/or signified clear, goal-oriented management	"Now [the FKNMS'] direction seems very clear and all about trying to make sure we preserve this reef and that we do the best we can to manage it properly." - Representative, Sanctuary Advisory Council (FKNMS)

Culture and Norms (2.3)		
Subcomponents	**Subcomponent Description**	**Example**

Stakeholder Inclusion	Any mention of instances where local and regional stakeholders were engaged	"The rewrite of the Restoration Blueprint has taken forever. They ended up doing hundreds of sessions, with the community and people involved" - Stakeholder, Sanctuary Advisory Council (FKNMS)
Public Outreach	Any mention of public education, outreach, awareness, and/or interaction	"As awareness gets better these perceptions are changing; it's easier to get the general public on board." - Representative, NOAA (SEFCRI)
Cultural Heritage	Any mention of the shared importance of the Florida Reef Tract and/or its value for future generations	"Now we have a political climate that's more understanding of, "[the Florida Reef Tract] is our lifeblood for Florida", and so we need to invest in it for so many reasons for the future." - Representative, Florida Department of Environmental Protection (SEFCRI)
Homogenization of Values	Any mention of what is collectively deemed acceptable in conservation including shared beliefs, knowledge, and values	"I just don't think that the people were on board to make it [the Restoration Blueprint] happen sooner. I don't know if there's been a shift in the people in charge or if it's just been a shift in the belief systems and the acceptance and willingness to move forward, but I feel like it has shifted into a good direction now, so I am more optimistic." - Representative, Sanctuary Advisory Council (FKNMS)

Issue Framing (2.4)		
Subcomponents	**Subcomponent Description**	**Example**
New/Changing Objectives	Any mention of new goals or objectives related to conservation	"I think that the issue of climate is not just a separate goal. Dealing with climate change is spread out through all of our goals and work in our organization at this point. There has been an evolving awareness and understanding of how to incorporate climate work." - Representative, Technical Advisory Committee (SEFCRI)
Novel Solutions	Any mention of new ways or approaches to solving problems	"The resource itself is the concern, but all the different entities that are managing the reef tract have different missions and priorities. We're looking toward a regional approach to consider the entire resource as an ecosystem." - Representative, Technical Advisory Committee (SEFCRI)
New Species Interactions	Any mention of specific species interacting in new ways	"Our theory is that the decline in the number of groupers -- the main predators of small fish such as damsels -- has allowed the damselfish to flourish and caused what biologists call a "phase shift" from one dominant life form to another in an area -- in this case, from corals to algae." - Researcher, University of South Florida (FKNMS)

New Ecosystem Functionality	Any mention of collective changes to the entire ecosystem	"This is a collapsed ecosystem now and with only a couple of exceedances and one violation, the whole Florida Bay ecosystem collapsed. That is something that definitely needs to be reevaluated so that the trigger/exceedance of violation occurs before the whole ecosystem collapses." - Representative, Sanctuary Advisory Council (FKNMS)
New Understanding	Any mention of new ideas, theories, or knowledge that has arisen as a result of novel conditions	"The world has changed and is changing in terms of what people are trying to do and what is happening to systems everywhere. There is a lot of information on this topic. The ecosystem is a different place today. It is important to think about the long term picture. Thirty years ago it would have been hard to know that the ecosystem would deteriorate so much even when it was being managed. This is why it is so important to think differently in this program in the Florida Keys." - Director, Office of National Marine Sanctuaries (FKNMS)
Anthropogenic Effects	Any mention of human-caused disturbance in the ecosystem	"Human activities that have added to worsening coral health include stormwater runoff, poor water quality, being hit by boat groundings and anchors, and coastal development." - Researcher, Technical Advisory Committee (SEFCRI)

Power and Authority (2.5)		
Subcomponents	**Subcomponent Description**	**Example**
Clearly Defined Roles and Responsibilities	Any mention of the definition, clarity, and acceptance of specific roles and responsibilities	"Florida Department of Environmental Protection's (DEP) leadership has heard you – especially as it relates to water quality. The department is the state's principal environmental agency, created to protect, conserve and manage Florida's environment and natural resources including the enforcement of federal and state environmental laws, protection of Florida's air and water quality, cleanup of pollution, regulation of solid waste management, and promotion of pollution prevention." - Spokesperson, DEP (SEFCRI)
Regulatory Enforcement	Any mention of new or existing regulations which were actively enforced	"SEFCRI successfully pushed for the Coral Reef Conservation Act of 2009, which assesses penalties against boaters who anchor or run aground on coral reefs." - Miami Herald (SEFCRI)
Compliance	Any mention of resources users complying with new or existing regulations	"The majority of fishing citations during this quarter were made on the bridges and were recreational in nature. There were not a lot of commercial violations at all." - Representative, Florida Fish and Wildlife Conservation Commission (FKNMS)

Institutional Changes	Any mention of instances where the redistribution of power or changes to overarching institutional values could be beneficial	"Under a reorganization plan working its way through NOAA, Causey would be named one of four regional managers for the National Marine Sanctuary Program. Dave Score, a former Upper Keys sanctuary manager, is slated to be named manager for the 2,900-square-mile Keys sanctuary." - Representative, Florida Fish and Wildlife Conservation Commission (FKNMS)
Procedural Changes	Any mention of new procedures for practice or the reallocation of responsibilities	"The Florida Fish and Wildlife Conservation Commission (FWC) recently passed a resolution reinstating licensing for commercial diving for spiny lobster in the Florida Keys. There has been a moratorium on commercial licenses for the past 10 years. The harvest by commercial divers is 3% of the total lobster harvest. With this change, there will be a limit of 255 transferable licenses." - Representative, FWC (FKNMS)
Perceived Legitimacy	Any mention of respect for and/or appreciation of existing authority and other power structures	"There's certainly pushback from the Community about certain aspects of the plan and certain members of the constituents that aren't happy with some of the proposed changes, but as a whole, you know I think the community embraces the conservation of a critical resource that you know the county relies on being healthy, in order to have a foundational economy for fisheries and eco-tourism and visitor use, so I think there's a lot of understanding, respect, and appreciation for the sanctuary." - Researcher, Sanctuary Advisory Council (FKNMS)

I begin my findings with my inclusion criteria (Table 3) which summarizes the novel ecosystem framework used as the basis for coding each data point (i.e., any mention of the concepts included in the framework and their subcomponents within the data). The criteria on the right operationalize the concepts and their subcomponents in the columns on the left. These criteria enabled me to determine whether a concept was present in the data, either as a positive mention or as negative criticism, or if the concept was absent altogether. Mentions of a concept are used as a proxy measure to determine the importance of the concept within the organization. The more a concept was mentioned or discussed, the more importance it was assigned by the organization.

Table 3. Inclusion criteria for quantitative coding.

Quantitative Inclusion Criteria

Concept	Definition	Criteria*
		* (1) indicates the presence of the concept; (0) indicates the absence of the concept; (+) indicates a positive mention of the concept; (-) indicates a criticism of the concept
Administrative Competence	Information about whether management is effectively conserving the ecosystem	(1) The presence of any subcomponents related to Administrative Competence (+) Positive examples include: managers incorporating scientific data into their decision-making processes; personnel being adequately trained and knowledgeable; the presence of iterative learning and cooperation; assessments conducted to ensure projects can feasibility be implemented (-) Criticisms include: decisions being made without consideration of scientific information; personnel inadequately prepared or absent from the decision making process; past mistakes and new information not being used to improve management; projects progressing without cost/feasibility assessments (0) The absence of this concept
Buffering	Information about whether management is adequately prepared for the future	(1) The presence of any subcomponents related to Buffering (+) Positive examples include: managers responding adequately to environmental changes; managers making decisions at the right times despite conditions of significant uncertainty; managers collecting enough data to inform decision-making; managers considering ways to improve resilience and manage uncertainty (-) Criticisms include: insufficient data collection; poor planning; managers not being prepared to implement new decisions when the time comes; managers not considering ways to reduce uncertainty and increase resilience (0) The absence of this concept

Culture and Norms	Information about whether management includes stakeholders, engages the public, and encourages a shared understanding	(1) The presence of any subcomponents related to Culture and Norms (+) Positive examples include: broad opportunities for inclusive public discourse and communication; overcoming enduring preferences for conventional management actions (e.g. protected areas, restoration to baselines, protecting specific species); shared objectives among stakeholders (the public, managers, scientists, fishers, developers); reaching common ground between actors (-) Criticisms include: failures to disseminate information to the public or decision makers; failures to foster an inclusive environment which promotes shared ideas and beliefs; a lack of public outreach; programs not meeting their objectives; instances of public confusion. (0) The absence of this criteria
Issue Framing	Information about whether management adequately considers anthropogenic impacts and novel solutions	(1) The presence of any subcomponents related to Issue Framing (+) Positive examples include: new ways of framing the problem of biodiversity and ecosystem decline; considering new species interactions, compositions, or ecosystem functionality; re-prioritizing objectives; re-defining what conservation means in the Anthropocene; describing different types of novel solutions. (-) Criticisms include: agencies and managers not addressing anthropogenic threats; failures to incorporate novel conditions into management discussion and decision-making (0) The absence of this concept

| Power and Authority | Information about whether management is well organized, capable, respected, and willing to consider change | (1) The presence of any subcomponents related to power and authority

(+) Positive examples include: the reallocation of rights and responsibilities; new procedures being implemented; roles and responsibilities are clearly defined and accepted; feasible opportunities have been identified where redistribution of power can occur; regulations are implemented and enforced

(-) Criticisms include: roles of different organizations are poorly defined; regulations were not enforced; ineffective changes to management plans or institutional structure; instances of mistrust between stakeholders and managers

(0) The absence of this concept |

Next, I examine the aggregate data generated using this inclusion criteria and use statistics to determine areas of significance. Then I begin to qualitatively explore why these results appeared.

(6.1) Aggregate Data
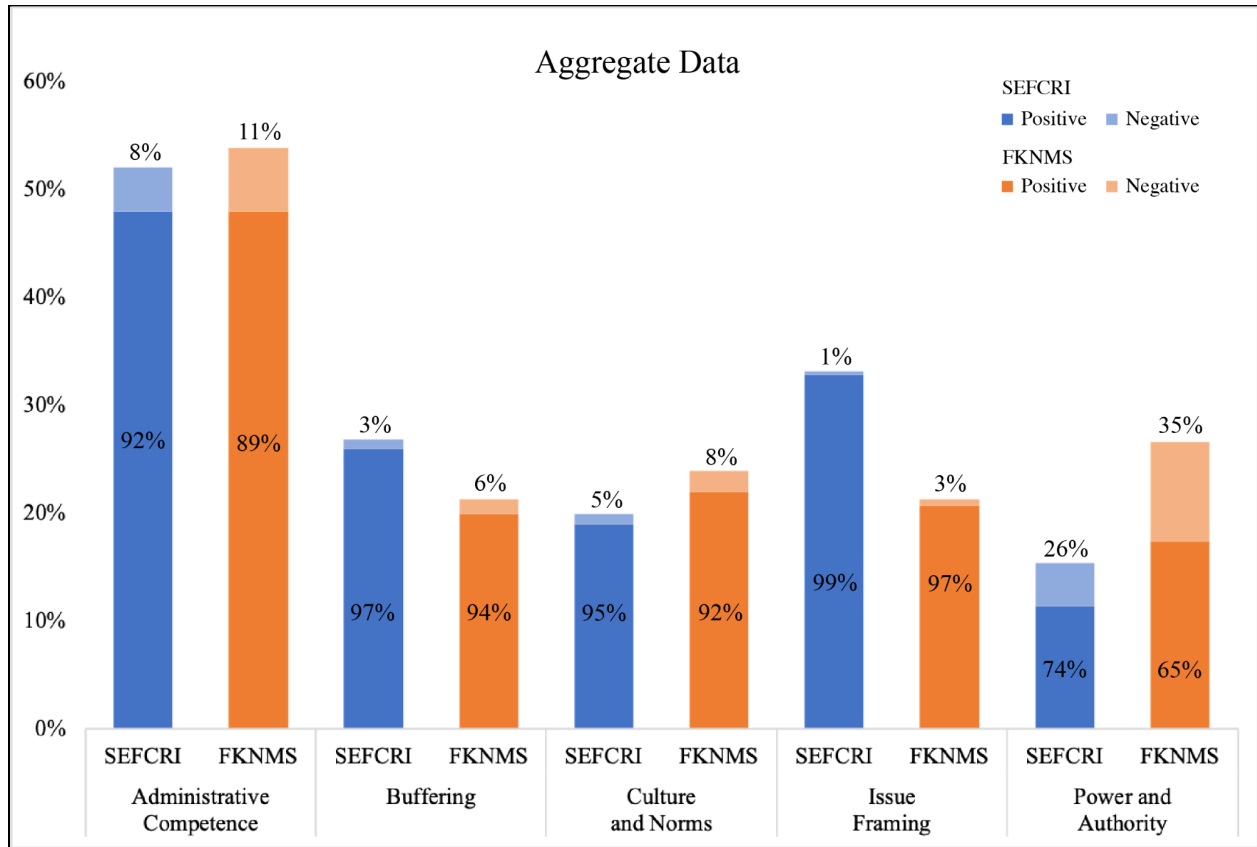
Figure 1. Each concept's overall frequency (i.e., percentage of messages with that code) is displayed on the *y-axis*. The different concepts are displayed on the *x-axis* as well as the management institutions. The percentages within each bar indicate each concept's positive mentions (i.e., positive instances) within the aggregate data. Likewise, the percentages at the top of each bar indicate each concept's negative mentions (i.e., criticisms) within the aggregate data. Percentages are rounded to the nearest whole number.

Table 4. Concepts, their definitions, proportions of aggregate mentions in the data, their test statistics and significance, and the results, including the *p*-values.

Difference in Proportions *t*-test for Concepts					
Concept	**Definition**	**FKNMS, *n* = 541**	**SEFCRI, *n* = 581**	**Test Statistic z score = (difference of sample proportions / pooled standard error)**	**Result**
Administrative Competence	Information about whether an institution is effectively conserving the ecosystem	0.53	0.52	0.34	The p-value is .738 The result is not statistically significantly different at $p \leq .10$

Power and Authority	Information about whether an institution is well organized, capable, respected, and willing to consider change	0.27	0.15	4.97***	The p-value is .00001 The result is significantly different at $p \leq .10$
Issue Framing	Information about whether an institution adequately considers anthropogenic impacts and novel solutions	0.21	0.33	-4.58***	The p-value is .00001 The result is significantly different at $p \leq .10$
Buffering	Information about whether an institution is adequately prepared for the future	0.22	0.27	-1.95*	The p-value is .051 The result is significantly different at $p \leq .10$
Culture and Norms	Information about whether an institution includes stakeholders, engages the public, and encourages a shared understanding	0.24	0.2	1.62	The p-value is .106 The result is not statistically significantly different at $p \leq .10$

*** Significant at $\alpha = 0.01$
** Significant at $\alpha = 0.05$
* Significant at $\alpha = 0.1$

This research used three data sources to code for the five concepts of the theoretical framework. I coded for mentions of each concept within the framework to examine the numerical importance of each concept to different governance systems with frequency used as a proxy for importance. On aggregate, *Administrative Competence* was the most frequently occurring concept within the dataset across both organizations (Figure 1). For SEFCRI, Administrative Competence was mentioned in 0.52 of the data. 0.92 of those mentions were positive, and 0.08 were negative. Meanwhile, for the FKNMS, Administrative Competence was mentioned in 0.53 of the dataset; 0.89 of those mentionings were positive, and 0.11 were negative. The aggregate Administrative Competence data are similar between the two organizations, although the FKNMS did have slightly more criticism. Between all of the mentions of Administrative Competence for both organizations, my two-tailed difference of proportions *t*-test showed that my results were not statistically significant at $p \leq 0.10$ (Table 4). This means that the importance or frequency of these mentions in the dataset were not statistically significantly different. Thus, Administrative Competence was an equally important concept in the FKNMS and SEFCRI cases.

On aggregate, *Buffering* was mentioned more often for SEFCRI than the FKNMS (Figure 1). For SEFCRI, Buffering was mentioned in 0.27 of the aggregate dataset; 0.97 of those mentions of Buffering were positive, while 0.03 were negative. For the FKNMS, Buffering was mentioned in 0.22 of the aggregate dataset. Within those mentions, 0.94 were positive, and 0.06 were negative. In this case, the two-tailed difference of proportions t-test showed that my results were significantly different at $p \leq 0.10$ (Table 4). This shows that Buffering was a more important concept in the SEFCRI case than in the FKNMS case.

Next, on aggregate, Culture and Norms were mentioned in 0.20 of the dataset. 0.95 of those mentions were positive, and 0.05 were negative. In the case of the FKNMS, Culture and Norms were mentioned more often in 0.24 of the aggregate dataset (Figure 1). Of those mentions, 0.92 were positive, and .08 were negative. In this case, between all of the mentions for both organizations, my two-tailed difference of proportions t-test showed that these results were not significantly different at $p \leq 0.10$ (Table 4). This means that their importance or frequency of mentions in the dataset was not statistically significantly different. Culture and Norms were an equally important concept in the FKNMS and SEFCRI cases.

On aggregate, *Issue Framing* had the largest difference in positive mentions between the two organizations (Figure 1). For SEFCRI, Issue Framing was mentioned in 0.33 of the aggregate dataset; 0.99 were positive mentions, and 0.01 were criticisms. Meanwhile, for the FKNMS, Issue Framing was mentioned in 0.21 of the aggregate dataset. Similarly to SEFCRI, 0.97 of the mentions were positive, while only 0.03 were negative. When looking at the data, criticism did not play a significant role in Issue Framing; rather, positive mentions dominated the dataset (Figure 1). Between all of the mentions for both organizations, my two-tailed difference of proportions t-test showed that these results were significantly different at $p \leq 0.10$ (Table 4). These findings show that issue framing was more important in the SEFCRI case.

Finally, on aggregate, *Power and Authority* was positively mentioned the least often and was also the most heavily criticized, making it a point of interest for this research (Figure 1). For

SEFCRI, Power and Authority was mentioned in 0.15 of the aggregate dataset; 0.74 of those mentionings were positive, and 0.26 were negative. Meanwhile, for the FKNMS, Power and Authority was mentioned in 0.27 of the aggregate dataset; 0.65 of those mentionings were positive, and 0.35 were negative. Overall, the FKNMS received more criticism than SEFCRI. Between all of the mentions for both organizations, my two-tailed difference of proportions *t*-test showed that these results were significantly different at $p \leq 0.10$ (Table 4). Power and Authority was more important in the FKNMS case than the SEFCRI case.

(6.2) Iterative Learning
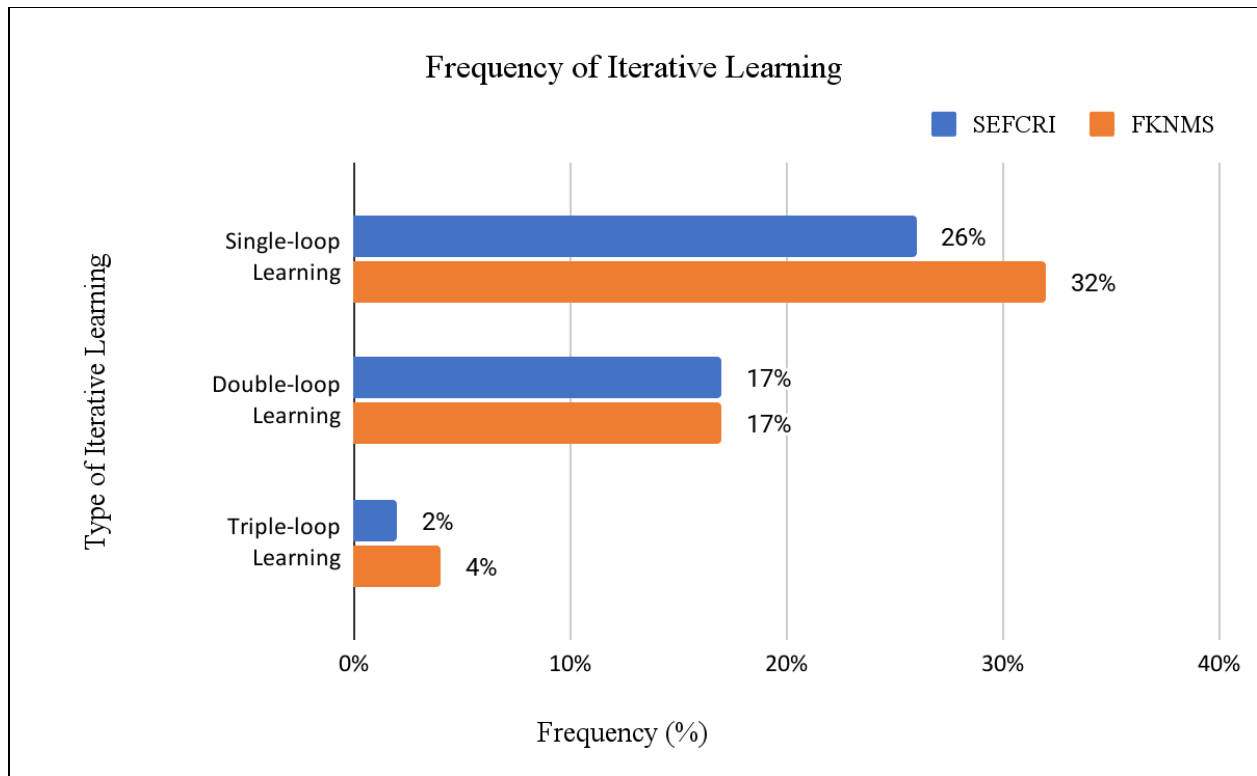
Figure 2. The overall frequency (i.e., percentage of messages with that code) of single, double, and triple-loop learning in the aggregate dataset for each institution are displayed on the *x-axis*. The different levels of learning are displayed on the *y-axis*. Percentages are rounded to the nearest whole number.

Table 5. Types of learning, their definitions, proportions of aggregate mentions in the data, their test statistics and significance, and the results, including the *p*-values.

Difference of Proportions Two-Tailed *t*-test

Type of Learning	Definition	FKNMS, $n = 541$	SEFCRI, $n = 581$	Test Statistic	Result
Single-loop	Day-to-day management actions that demonstrate incremental improvements towards meeting management goals	0.32	0.26	2.22**	The p-value is .026926 The result is statistically significantly different at $p \leq .10$
Double-loop	Instances where guiding assumptions are questioned about how management goals can be achieved, leading to the development of new management approaches	0.17	0.17	0	The p-value is 1 The result is not statistically significantly different at $p \leq .10$
Triple-loop	New actors joining networks, changing power structures, and introducing new regulatory frameworks through iterative, adaptive governance	0.04	0.02	1.95**	The p-value is .050902 The result is statistically significantly different at $p \leq .10$
*** Significant at $\alpha = 0.01$ ** Significant at $\alpha = 0.05$ * Significant at $\alpha = 0.1$					

Here, I present the single, double, and triple-loop learning data (Figure 2). Single-loop learning dominated the aggregate data set, as it is the most common type of learning and reflects day-to-day management actions, while triple-loop learning was rarely seen. Overall, the FKNMS exhibited more instances of single and triple-loop learning. For the FKNMS, single-loop learning appeared in 0.32 of the data, double-loop learning appeared in 0.17 of the data, and triple-loop learning occurred in 0.04 of the data. For SEFCRI, single-loop learning appeared in 0.26 of the data, double-loop learning appeared in 0.17 of the data, and triple-loop learning occurred in 0.02 of the data. While triple-loop learning was rare, double-loop learning was still common. My results also show that double-loop learning was identical between the two organizations, reflecting that both institutions often questioned the guiding assumptions about how their management goals could be achieved. This is important because it illustrates progress towards institutional change, like what appears in triple-loop learning. Between the two organizations, the two-tailed difference of proportions of t-test of single-loop and triple-loop learning were both statistically significantly different at $p \leq 0.10$ (Table 5). This suggests single-loop learning was

occurring more often in the FKNMS, double-loop learning was occurring at the same level in both cases, and triple-loop learning was occurring more frequently in the case of the FKNMS.

(6.3) Summary of Supplementary Data

In addition to the aggregate data, I took a closer look at how frequently each concept was mentioned within the different forms of data: *news*, *meeting minutes*, and *interviews*. In some instances, taking a closer look at the context in which a speaker mentioned a concept provided additional details. For example, most criticisms for both institutions occurred within the interviews, a fact which I discuss later, but relays the importance of utilizing a diverse dataset to triangulate findings and collect information which was not present in the meeting minutes alone. Another example was the abundance of criticism in the data from the news for the FKNMS in relation to Power and Authority. Within that dataset, especially surrounding management plan rewrites, news media reflected citizens' concerns who felt the government was inappropriately limiting their access to natural resources. Seeing these differences helped to validate my findings and generate opportunities for further research. A thorough breakdown of this data, including visualizations, can be found in Appendix C.

(6.4) Aggregate Criticisms

Next, I examine the criticisms seen in the aggregate data (Figure 3). These criticisms were important because they highlight areas where improvements could potentially be made.
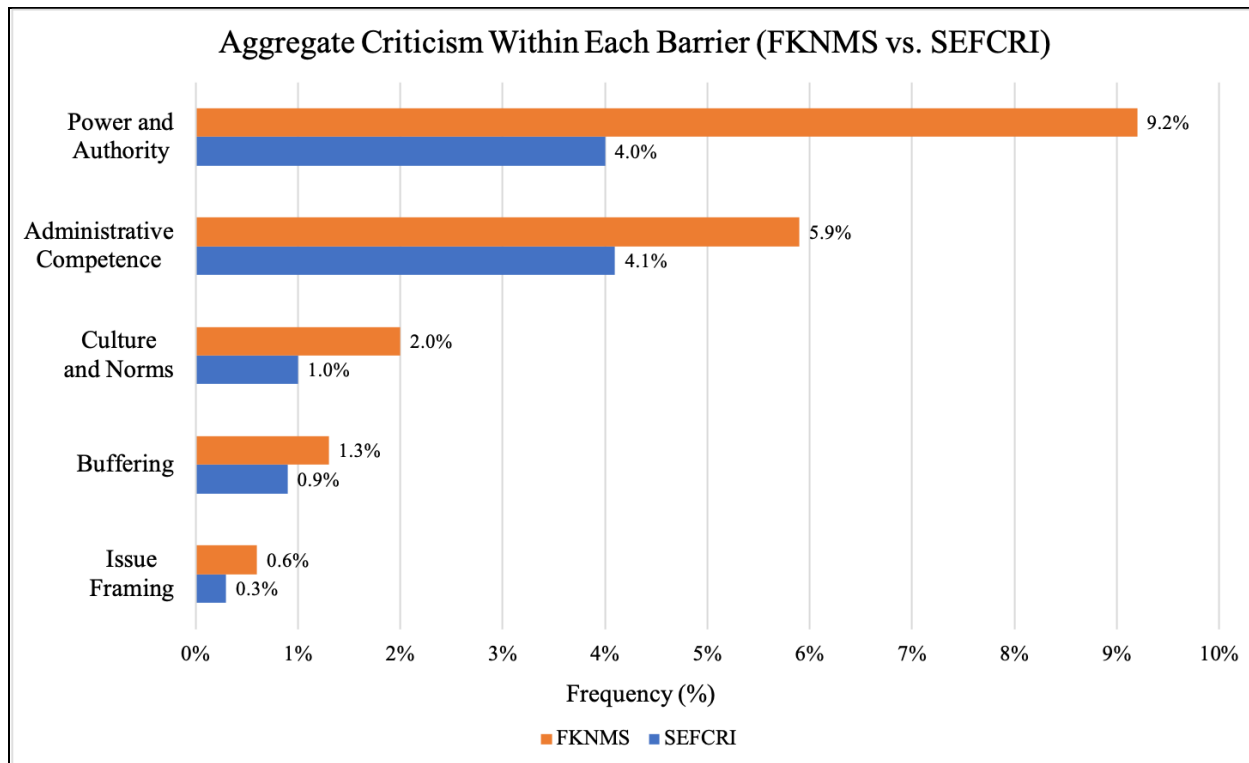
Figure 3. The different concepts are displayed on the *y-axis*. The overall frequency of criticisms in the aggregate dataset for each concept is displayed on the *x-axis*. Percentages are rounded to the nearest whole number.

On aggregate, the most criticisms of the FKNMS were observed concerning Power and Authority (0.09; Figure 3). Criticisms of Power and Authority made up just over 0.09 of the total FKNMS dataset. As a reminder, for each concept and subcomponent listed in this section, refer to Table 2 for a definition of each and a general example. For instance, within Power and Authority, the subcomponent *Perceived Legitimacy* (i.e., the respect and appreciation of existing authority structures) for the FKNMS was, on aggregate, most often criticized. The following quote from the news data reflects an instance of Perceived Legitimacy being criticized for the FKNMS:

> "They [the FKNMS] are overreaching and getting into fishery management, which is an area they should not be," [said a prominent Key West charter captain and former sanctuary adviser]. "They're trying to say it's not fishery management, but when they take enormous swaths of ocean and say you can't fish there, that's the ultimate in fishery management," [this stakeholder] said." - Florida Keys Keynoter

This quote is an example of a charter captain who feels that the FKNMS has encroached on his rights to fish. Therefore, he does not perceive their Power and Authority to be legitimate in this instance and thus criticizes the FKNMS.

The second most criticized concept for the FKNMS was Administrative Competence (Figure 3) which occurred in 0.06 of the aggregate dataset. Within Administrative Competence, the subcomponent *Effective Resource Management* (i.e., management actions, policies, regulations, or programs that directly benefit conservation) was most often criticized. For example, the following quote from the news data shows an instance of Effective Resource Management being criticized for the FKNMS:

> "However, despite the efforts of marine scientists, conservation groups, and federal and state officials, politically powerful recreational and commercial fishers succeeded in persuading authorities to reduce the amount of the Florida Keys sanctuary devoted to no-take zones from 20 percent of the total in the original plan to less than 0.5 percent." - Chronicle of Higher Education

In this case, the management area was significantly reduced despite scientific recommendations from FKNMS officials and other managers. Therefore, criticism covers the loss of conservation actions in the FKNMS. Similarly, the highest level of criticism for SEFCRI was for Administrative Competence (0.04). Effective Resource Management was the most heavily criticized subcomponent therein. The following quote from the interview data shows an instance of Effective Resource Management being criticized for SEFCRI, where one member of the Technical Advisory Committee felt that SEFCRI had not sufficiently implemented management actions as a part of the Our Florida Reefs initiative.[17]:

> "SEFCRI, to a large extent, failed with the management actions that were proposed as part of [the] Our Florida Reefs [program]. You can go back in history and look at [...] the SEFCRI Our Florida Reefs recommendations—they're all documented. I mean, massive reports with dozens, if not hundreds of proposed activities - most of which are simply archived with no action taken." - Interview Respondent 4, SEFCRI Technical Advisory Committee

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[17] The Our Florida Reefs initiative is a community planning process, spearheaded by SEFCRI, which aims to increase community awareness and involvement with the reef. For more information, visit: https://ourfloridareefs.org/

SEFCRI also had a similar frequency of criticism for both Administrative Competence and Power and Authority (Figure 3); criticism of Power and Authority in the SEFCRI data was also 0.04. Within the Power and Authority data, the subcomponent *Clearly Defined Roles and Responsibilities* (i.e., definition, clarity, and acceptance of specific roles and responsibilities) was most heavily criticized. The following quote from the meeting minutes data shows an instance of Clearly Defined Roles and Responsibilities being criticized:

> "I mean they [SEFCRI] have done a really good job of coordinating all the different agencies, but it still seems like, now that I am on the outside, [that] it is not all figured out who should be doing what." - Interview Respondent 9, SEFCRI Technical Advisory Committee

7. Qualitative Findings

This section discusses each of the five concepts for novel ecosystem management, discussing their meaning according to the data I analyzed, detailing criticisms from stakeholders found in the data, and insights from iterative learning.

(7.1) Administrative Competence

The concept of *Administrative Competence* was defined as information on whether conservation practitioners have the basic skills, knowledge, and resources required to manage a novel ecosystem effectively and included six subcomponents: 1) *Structured Decision Making,* 2) *Due Diligence,* 3) *Effective Resource Management,* 4) *Feasibility,* 5) *Technical Know-How,* and 6) *Cooperation* (Table 2.1). To help showcase the differences between the different data types, six representative quotes, three from each organization, describe instances of *Administrative Competence* in the data collected separately from news, meeting minutes, and interviews. These quotes are displayed in the table below (Table 6).

Table 6. Examples of Administrative Competence from the data.

Administrative Competence	
News	
FKNMS	"Today, NOAA's Office of National Marine Sanctuaries released a draft proposal recommending a range of potential changes to existing boundaries, regulations, and marine zones in the Florida Keys National Marine Sanctuary, to better address long-term declines to the region's marine resources as well as ongoing and emerging threats due to changing ocean conditions." - Targeted News Service
SEFCRI	"The purpose of the cleanups is to remove marine debris from the reefs that lie just offshore in Southeast Florida," said Joanna Walczak, Florida Coastal Office's southeast regional administrator. "In addition, we hope to educate divers about the damages that debris can inflict on the coral reef ecosystem, encourage them to look for debris during every dive, and pick up and report what they find." - U.S. State News
Meeting Minutes	

FKNMS	"The sanctuary program doesn't have an aversion to artificial habitats as long as they "fit". As with everything, the project would have to meet the requirements of the National Marine Sanctuaries Act. It is all about what the project is trying to accomplish and how it will be done—whether it helps sustain the ecosystem, economy and way of life." - Director, Office of National Marine Sanctuaries
SEFCRI	"We are prioritizing management actions over research right now because SEFCRI is 10 years old right now. We have data and research that is sitting on a shelf, but we need actions to start taking place right now. That is our focus to move things forward on actions." - Manager, Florida Department of Environmental Protection, Coral Reef Conservation Program
Interviews	
FKNMS	"We protected the reef from large ships, we haven't had a large ship grounding since then. At that point we had an area to be avoided, now we've got beacons. I mean the capability of the electronics now is so great that it's almost unnecessary but, at the time it was critical." - Interview Respondent 2, Sanctuary Advisory Council
SEFCRI	"Then, Our Florida Reefs came and it was a big push to try and get some concrete protections of our reefs, and they did a great job to have public meetings—launching it, the onboarding, the process, and then kind of closing the process out—but lots of meetings with all kinds of stakeholders, not just the SEFCRI team" - Interview Respondent 9, Florida Department of Environmental Protection, Coral Reef Conservation Program

For the FKNMS, Administrative Competence was characterized mainly by regulatory actions and leadership for those actions. Specific actions within the FKNMS that constituted Administrative Competence included managers making changes to the existing management plan, new proposals for protected areas, marine zoning (e.g., no-take areas), fisheries regulations, water quality protection programs, and permitting for artificial reef structures. The quotes listed in Table 6 reflect these concepts, which were often action-oriented. A representative quote from the Sanctuary Advisory Council meeting minutes in 2019 showed that when an experimental protected area (the Dry Tortugas Research Natural Area) was identified as having been an effective MPA, it was quickly reinstated—an example of active resource management: "These data, which were presented to FWC Commissioners, show that the Dry Tortugas Research Natural Area was an effective MPA that now has been reinstated for another 20 years."

Alternatively, Administrative Competence for SEFCRI focused more on preventative measures. A policy priority was placed on data collection, such as altering harmful nutrient flows

to prevent eutrophication and surveying for Stony Coral Tissue Loss Disease. Two common areas of focus were assessing the feasibility of preventative actions to reduce stressors, and incorporating the process of structured decision-making. Focusing on the subcomponents *Structured Decision Making* and *Feasibility* resulted in SEFCRI's overall Administrative Competence prioritizing possible management actions, cooperation, management goals, monitoring, education, and outreach. One representative quote from SEFCRI's meeting minutes in 2015 highlights the extent of its focus on preventative measures and data collection while also highlighting the need to shift towards more active management practices:

> "We have data and research that is sitting on a shelf, but we need actions to start taking place right now. That is our focus to move things forward on actions. We may not be focusing on research right now but it does not mean we will not be doing research. We just want to implement some of the results from previous research before moving on." - Manager, Florida Department of Environmental Protection

To better highlight these core differences, I break down Administrative Competence further by each of its six subcomponents and compare them across both organizations using representative quotes, beginning with *Structured Decision Making*.

Structured Decision Making included any mention of decision-making processes that utilized elements such as management objectives, options, and predictions to make informed decisions. For the FKNMS, this subcomponent appeared concerning new proposals for zoning, regulations, or changes to current management. For example, take this quote from a Sanctuary Representative in the news data, "We're seeking information on actions and activities that may affect the status of the corals, and the existence and efficacy of ongoing conservation activities."

In some cases Structured Decision Making looked very similar for SEFCRI, like this quote from the news data, "Experts at a recent meeting [...] discussed another possibility: route the discharge to inland waters, where the nutrient-heavy effluent could nourish a man-made mangrove area." However, other times the preparatory nature of SEFCRI (focusing more on data collection and preventive measures) became more apparent, such as in this quote from the meeting minutes data, "What changes should be made to the current water quality assessment in

order to meet the goals you described? [...] It may be that nothing needs to be changed." Discussing alternatives (even the option to "do nothing") is an example of Structured Decision Making, which plays a role in making the best possible decisions.

Due Diligence included any mention of extra steps being taken to ensure that facts, details, or concerns were being adequately considered. First, consider this example from the FKNMS Sanctuary Advisory Council meeting minutes, "In general, the U.S. Army Corps must coordinate with other agencies and incorporate their comments, and that takes time." This is an example of strong leadership taking sufficient steps to ensure the decision-making process is done correctly. Alternatively, for SEFCRI, an example of Due Diligence can also be found in their Technical Advisory Committee meeting minutes, "We still have the narrative that [Stony Coral Tissue Loss Disease] began in Miami in 2014, but there is data that suggests it began in 2013. The accurate start of the disease is important to know and get right." This example highlights an instance of quality assurance, where the SEFCRI team is considering all the appropriate data to address scientific uncertainties over increasingly severe coral disease outbreaks.

Effective Resource Management included any mention of management actions, policies, regulations, or programs that are directly beneficial to conservation. This first quote from the FKNMS meeting minutes highlights an instance of a direct intervention, "Without sponge habitat, the shrimp disappear, and the ecosystem loses diversity. To combat this loss, the Florida Fish and Wildlife Conservation Commission is working to propagate sponges in nurseries and outplant 15,000 sponges by the end of 2019." Alternatively, this quote from the SEFCRI news data highlights their information gathering and general preparedness:

> "On Wednesday [SEFCRI] released a draft of an ambitious list of goals for research and protection of hard corals [...] 'we're in the information-gathering mode at this point,' [...] This is bringing everybody to the table and addresses all the questions at once."

Feasibility included any mention of considerations for the practicality of management actions. For the FKNMS this was mentioned less often, but included discussions like the expansion of habitat protections, disseminating roles and responsibilities, or including stakeholder feedback. For example take this quote from the Sanctuary Advisory Council:

> "What's come through [the working group] is pretty decent," said [a commercial fisherman] serving on the panel. We might hear different things from fishermen in other parts of the Keys but it's very hard to please everybody [...] We're trying to do what's best for the environment."

Alternatively, SEFCRI often mentioned Feasibility concerning the availability of funding, incorporating the right information, and working within their means. For example, consider this quote from the meeting minutes, "So, the corals right now are totally stressed, what is the most cost-effective measure [...] that we can take now? We need do-able measures that are backed by science and can be taken to the public."

Technical Know-How included mentioning the specific knowledge, skills, and expertise that managers possess. For the FKNMS, this was a broad topic but often included instances where leadership or decision-making roles were vetted. For example, consider this quote from the Sanctuary Advisory Council Meeting Minutes, "During [their] 20 years at NOAA, mostly in fisheries, [they] served as acting deputy director at NOAA's National Center for Coastal Ocean Science. [They] have specialties in protected species [and] international treaty work." For SEFCRI, Technical Know-How also centered around the expertise of team members and decision-makers but was often paired with improved cooperation, data collection, and new ideas. For example, consider this quote from a manager at the Florida Department of Environmental Protection speaking about team selection for the Our Florida Reefs Initiative, "We went with this team because it's respected by the fishing community and works with fishers in the human dimension; that's their expertise."

Lastly, *Cooperation* included any mention of people, agencies, or institutional elements working together towards a common goal. Cooperation was common for both organizations. For

the FKNMS, Cooperation often included stakeholder involvement, agency involvement, collaborations with interest groups, regulatory enforcement, and project implementation. For example, consider this quote from Interview Respondent 1:

> "We have been working with members of the sanctuary for a very long time[...] They've been great at helping guide our research and our restoration activities [...] and restoration groups so that you know we're complementing each other and sharing information. They have always been a great group of people, and a great organization to work with."

For SEFCRI, Cooperation included stakeholders, public outreach initiatives, volunteer coordination, workshops, and collaborations with participating organizations. For example, consider the following quote from the Technical Advisory Committee, "Additionally, we suggest ensuring closer collaboration between any technical group and the Technical Advisory Committee of the Southeast Florida Coral Reef Initiative, as well as the Florida Reef Resilience Program."

(7.2) Buffering

The second concept, *Buffering*, was characterized by the ability of managers to cope with uncertainty through directing adequate responses to the proper drivers while managing social and ecological influences on the ecosystem. As a reminder, Buffering refers to whether actors (i.e., state or federal agencies, non-governmental organizations, universities, etc.) are adequately prepared to tackle the problem at hand while under conditions of considerable uncertainty. In this case, coral reef conservation in the Anthropocene where the ultimate impacts of climate change and other threats remain to be seen. Buffering included four subcomponents: *Preparedness, Managing Uncertainty, Sufficient Data Collection,* and *Directional/Proportional Responses* (Table 2.2). Six representative data points, three from each organization, describe instances of *Buffering* in the data collected separately from news, meeting minutes, and interviews. These quotes are displayed in the table below (Table 7).

Table 7. Examples of Buffering from the data.

Buffering	
News	
FKNMS	"The survey, from the University of Massachusetts at Amherst, is legitimate," said Karrie Carnes, communications director for the Florida Keys National Marine Sanctuary. "It's part of a study that follows up on a similar study from 1995 and 1996," she said. "The sanctuary and other resource managers make use of the information in planning." - Florida Keys Keynoter
SEFCRI	"The Our Florida Reefs Community Working Group members are crafting recommendations to balance use and protection of southeast Florida's coral reefs using the best available science, but they cannot complete their task without information about the diverse interests of all ocean users," said Jamie Monty, manager of the Florida Department of Environmental Protection Coral Reef Conservation Program and chair of the SEFCRI team. "We're thrilled to launch the Our Florida Reefs Coastal and Ocean-use Survey to ensure this important information is captured and used during this process." - Targeted News Service
Meeting Minutes	
FKNMS	"The discharges that occur through the Caloosahatchee [River] and St. Lucie [Inlet] are still problematic, even though discharges will be less when the Central Everglades Planning Project is in place. This is why additional storage is needed north of the lake. Part of restoration involves reducing unintended consequences of this managed system." - Policy Coordinator, Office of Everglades Policy and Coordination
SEFCRI	"We are trying to develop a set of relevant parameters that can be used as indicators to detect potentially harmful effects. I don't know if the next event will be another disease outbreak. It could be algae, it could be something that we cannot imagine here, so how can we detect, into the future when something happens. We are trying to move from being reactive to more proactive." - Manager, Florida Department of Environmental Protection, Coral Reef Conservation Program
Interviews	
FKNMS	"We see lots of beacons of hope out there, we have some sites that are doing really amazingly after restoration occurs, and we try to integrate resilience into our restoration activities so that they can withstand climate change, at least in the near future and, hopefully, are more resistant to things like diseases. But, we also recognize that there are those major issues you need to get addressed in order for those restoration successes to be long term." - Interview Respondent 1, Sanctuary Advisory Council
SEFCRI	"We've learned a lot about restoration, we've harvested tissue to ensure genetic diversity and healthy populations, so that's my hope and outlook on the future of the reef tract—getting it into a position where it can be restored." - Interview Respondent 8, Technical Advisory Committee

In some cases, the concept of Buffering was defined similarly across both organizations. Concerning future threats, both organizations mentioned subcomponents of Buffering when

discussing concerns for the Florida Reef Tract, such as climate change, new species interactions, coral disease, maintaining sufficient genetic diversity, and water quality. For the FKNMS, discussion of these concerns was often paired with suggestions for new zoning, new proposals, and new regulations. Some unique topics included issues like emerging areas of concentrated visitor use in the Florida Keys, the increasing salinity of Florida Bay, and fisheries management. Another difference was that the FKNMS was able to incorporate more past projects that were conducted within the Sanctuary to inform future management decisions. For example, take this quote from the Director of the FKNMS, "We have some new science and condition reports to show what's working and where changes may need to be made."

In contrast, SEFCRI often appeared to be in the process of collecting novel types of data and implementing new projects (Table 7). However, this novel data collection was an important task because much of the northern reaches of the Florida Reef Tract had not been mapped until recently. For example, this representative data point on Buffering from the news data mentions the novel research being conducted along the northern Florida Reef Tract:

> "The Florida Department of Environmental Protection's Coastal and Aquatic Managed Areas' Coral Program completed its portion of data collection dives on more than 250 sites spread across 110 miles of the Florida Reef Tract that runs north from Biscayne National Park in Miami-Dade County to the St. Lucie Inlet in Martin County. The completion of this new survey on the northern portion of the reef marks the first time the entire Florida Reef Tract has been documented using the same method."

SEFCRI often mentioned Buffering in relation to public outreach and curbing the environmental impacts of dense population centers like Miami and Fort Lauderdale, which have more direct links to water quality issues to consider like surface runoff, drainage outflows, and other anthropogenic point source pollutants, many of which are regionally distinct from the Florida Keys. For example, take this representative quote from a member of SEFCRI's Technical Advisory Committee:

> "[You] have to accept that there are going to be different pressures [...] I don't know what the population is in the Florida Keys, but setting aside the tourists, it's tiny in comparison to the population [In Miami-Dade], so there are different pressures from that point of view. What you

might be able to do in the Keys, you're not able to do here. [...] And, of course, from population comes water quality, comes fishing pressure, comes diving pressure as well." - Interview Respondent 4

To help explain these findings for SEFCRI and the FKNMS, I break down Buffering further by each of its four subcomponents and compare them across both organizations using representative quotes, beginning with *Preparedness*.

Preparedness included any mention of actions taken to ensure that managers have the tools necessary for data collection. For the FKNMS, this subcomponent included topics like implementing artificial reefs, improving water quality, fisheries management, and species interactions. For example, consider this quote from the Sanctuary Advisory Council discussing the need to understand the potential impacts of artificial reefs, "More information is needed on the long term effects of these structures in terms of colonization and how they affect the surrounding environment. The scientific monitoring has sometimes been overlooked, but is very important to pursue." For SEFCRI, Preparedness was often related to topics like the Stony Coral Tissue Loss Disease, monitoring, and reef resilience. Consider this quote from Interview Respondent 6, which showcases preparatory actions that would yield valuable data and support other subcomponents like Managing Uncertainty:

> "[Stony Coral Tissue Loss Disease] traveled North and South from [Miami-Dade], and so we jumped ahead of it to find clean coral. Then our job was to collect representative samples of stony coral that we figured we were going to lose."

Managing Uncertainty included any mention of the tools, programs, or procedures which help managers defend against unforeseen future disturbances. For the FKNMS, Managing Uncertainty was mentioned in relation to topics like managing protected areas, ecosystem restoration, and the feasibility of artificial reefs. In some cases, contingency plans were even discussed, which would enable the FKNMS and its participating agencies to respond adequately in worst-case scenarios. For example, take this quote from a Sanctuary Advisory Council Meeting:

"The United States Coast Guard had a [preparatory] exercise in accordance with our Area Contingency Plan last week. They simulated a worst case [pollutant] discharge and participated with port partners to draw up a tabletop plan. The event was well attended and involved a great discussion about how each agency/trustee would respond."

Examples like this accentuate the long-standing formal structure of the FKNMS and the participating agencies within, where more direct measures are abundant, and greater resources can be brought to bear. For SEFCRI, Managing Uncertainty often meant collecting robust scientific data and thus was closely tied to the subcomponent *Preparedness*. For example, consider this quote from Interview Respondent 12, "I think [...] the research for [coral disease], coral bleaching, and acidification, that all has to keep happening and then those organizations who are [ensuring genetic diversity] in the lab, [that] all has to just keep going."

Sufficient Data Collection included any mention of robust data collection, which helped to clarify the status of the ecosystem or provide relevant predictions for management. This looked very similar between the FKNMS and SEFCRI, where both emphasized Sufficient Data Collection in conjunction with Preparedness yet still displayed some institutional differences. For example, consider this quote from the FKNMS meeting minutes data, "[Data] can influence decisions and support was expressed for utilizing this information to put additional zoning in place. Science is very important, and new science on this topic is needed." This quote emphasizes how data collection was often used for zoning and regulations by the FKNMS. Alternatively, consider this SEFCRI quote from a Florida Department of Environmental Protection representative in the news data, which helped to achieve a greater understanding of the northern reef tract:

"This same sampling protocol was recently approved by [NOAA]. Not only will this data provide the first holistic snapshot of the fish population across the Florida Reef Tract, it will allow for greater consistency of resource management actions in Florida and the Atlantic/Caribbean region. This will ultimately increase awareness of, and protection for, Florida's economically and ecologically valuable coral reef and fish resources."

Finally, *Directional/Proportional Responses* included any mention of responses that matched the scale of a problem and/or signified clear, goal-oriented management. For both the

FKNMS and SEFCRI, this subcomponent spanned a broad range of topics. For the FKNMS, this included new regulations to protect corals, reevaluation of management strategies, new zoning, coral reef restoration projects, and reducing invasive species. For example, consider this quote from the news data:

> "NOAA's press release said that dispatching trained divers to collect the individual [lionfish] is the only effective elimination method for this invasive species. Because the deepwater reef habitats along the southeast coast of the United States and the Bahamas span 62,000 square miles, the cost and effort of this technique is "impractical." However, [a representative] said that removal by divers is a possibility to prevent [the] establishment of lionfish in the National Marine Sanctuary."

For SEFCRI, discussion of this subcomponent centered around new possibilities like the feasibility of no-take zones, new surveys, or opportunities for collaboration. Proportional responses also involved responding adequately to emerging anthropogenic threats and increasing public outreach. For example, consider this quote from Interview Respondent 12:

> "Whenever I give any sort of environmentally related talk [...] I always try to end it on an upswing [...] Humans have caused, unfortunately, a major negative impact. So, "what can you do," well, [it] might just be individual at first, but if you get five people and then 10 people [involved] they can be impactful. So, that is the whole idea behind the Local Action Strategies—they're trying to address local threats."

(7.3) Culture and Norms

The third concept, *Culture and Norms*, included the following components: whether an institution prioritizes stakeholders, engages the public, and encourages a shared understanding amongst both managers and the public. Therefore, this concept included four subcomponents: 1) *Stakeholder Inclusion;* 2) *Public Outreach;* 3) *Cultural Heritage;* and 4) *Homogenization of Values* (Table 2.3). Six representative data points, three from each organization, describe instances of *Culture and Norms* in the data collected separately from news, meeting minutes, and interviews. These quotes are displayed in the table below (Table 8).

Table 8. Examples of Culture and Norms from the data.

Culture and Norms	
News	
FKNMS	"NOAA will accept public comment on the proposals through January 31. The public comment period will span two sanctuary advisory council meetings and will include opportunities for engagement, including public meetings." - Targeted News Service
SEFCRI	"SEFCRI will present a series of free workshops for the marine tourism industry during May in Broward, Miami-Dade and Palm Beach Counties entitled 'Coral Reefs & Sustainable Marine Tourism: Protect Your Business by Protecting Your Reef.' The workshops will feature international and local experts to discuss the socioeconomic value of coral reefs, innovative local solutions and how to market sustainability." - U.S. States News
Meeting Minutes	
FKNMS	"A high-level report card with status and trends for each U.S. coral reef area is being developed and will serve to inform the public and managers involved in decision-making." - Program Coordinator, NOAA
SEFCRI	"A precautionary principle should be included under science-based approaches. Secondly, we need to appreciate local knowledge. Sometimes we don't have the science, but there is lots of local knowledge that could be leveraged." - Researcher, College of Charleston
Interviews	
FKNMS	"That took over a year of public comment and now it's in the rewrite phase and it will be most likely coming out this summer, early fall, with 'this is the final proposed rule,' and at that point it will go back open for public comment." - Interview Respondent, Sanctuary Advisory Council
SEFCRI	"Between agencies and counties we're all of the same mind, but it's different when dealing with the public. Everyone kind of has their own agenda, and their problems are the greatest, so you have to kind of do triage to find out what is the biggest issue and what needs to be prioritized." - Interview Respondent 18, Technical Advisory Committee

The concept of Culture and Norms was qualitatively different between the FKNMS and SEFCRI. The most important difference was between *Stakeholder Inclusion* and *Public Outreach*. While both organizations had instances of both subcomponents, the FKNMS emphasized Stakeholder Inclusion in management more often, while SEFCRI focused more on Public Outreach. The SEFCRI data contains public service announcements, education campaigns, engagement with public figures (e.g., celebrity Guy Harvey), and workshops related to raising awareness about the Florida Reef Tract. For example, the Our Florida Reefs initiative

that SEFCRI spearheaded was a community-led campaign with a marked presence in the data. The following quote represents an instance where Public Outreach was emphasized by leaders from the Department of Environmental Protection's Coral Reef Conservation Program:

> "We are thrilled to have [conservation celebrity] Philippe Cousteau lend his voice to the Our Florida Reefs' campaign [...]It was also an honor for him to use a Florida Department of Environmental Protection vessel as a platform to visit a thriving staghorn coral reef [Cousteau's] passion [...] shines through in his [public service announcement] and segments of the coral reef education episode filmed that day." - Targeted News Service

The Our Florida Reefs initiative included significant stakeholder involvement as well. For example, the Southeast Florida Action Network (SEAFAN) implemented a public system for reporting hazards to coral reefs such as marine debris, anchor damage, or harmful biological disturbances, such as coral bleaching (Our Florida Reefs, 2013). In sum, while Public Outreach stood out in the data, Stakeholder Inclusion was certainly not ignored.

In the FKNMS, stakeholder involvement was related to changes to the management plan, which often involved public comment sessions and town-hall style meetings. Sanctuary Advisory Council meetings were also held to elicit the preferences of local stakeholders, such as fishers who were likely to be impacted by new rules and regulations. For example, take this representative quote from an economist with the NOAA Office of Marine Sanctuaries:

> "Most commercial fishermen cited the public process that resulted in the creation of the no-take Tortugas Ecological Reserve within the Florida Keys sanctuary as the reason for changing their attitudes. That process really allowed the local community to have a say in the Sanctuary boundaries and regulations."

This data point demonstrates how Public Outreach is different from Stakeholder Inclusion, with outreach defined as public education and stakeholder engagement as stakeholders having their opinions considered in the decision-making process.

To help explain these findings, I also break down Culture and Norms further by each of its four subcomponents and compare them across both organizations using representative quotes, beginning with *Stakeholder Inclusion.*

Stakeholder Inclusion included any mention of instances where local and regional stakeholders were engaged. For the FKNMS, Stakeholder Inclusion often revolved around the elucidation of stakeholder opinions of lobster trapping, boating, fishing regulations, and the expansion of marine zoning. Stakeholder Inclusion was also mentioned as a way to increase transparency and reduce user conflict within the Sanctuary. For example, consider this representative quote from a member of the Sanctuary Advisory Council in the news data:

> "People seemed to relax a bit when they realized nobody is trying to shut down the Keys," [the representative] said. "I'm in the tourism business so the last thing I want to do is put anybody out of business. But, I think part of staying in business is preserving our ecosystem."

For SEFCRI, Stakeholder Inclusion also revolved around developing a new management plan, new workshops, disseminating information, and finding commonalities among different resource users. For example, consider this representative quote from a member of the Technical Advisory Committee:

> "Find common ground [like] projects or initiatives that those stakeholders can work on together. Give them responsibility for conservation in the SEFCRI region. Focus on conservation initiatives that don't necessarily impact them at first."

Public Outreach included any mention of public education, outreach, awareness, and/or interaction. For the FKNMS, this included topics like boater education courses, marine debris removal programs, education for tourists, improving public perceptions of the Sanctuary, and the Blue Star program, which recognizes sustainable diving, boating, and fishing practices. For example, consider this quote from a Sanctuary Advisory Council representative:

> "[The representative] explained that one objective was to recognize charter operators who meet set criteria regarding conservation of the ecosystem and education of their customers. Other objectives include increasing awareness of stewardship among residents and visitors, increasing

communication and partnerships between the sanctuary and recreational/charter community, and promoting the sanctuary as a multiple use recreational area."

For SEFCRI, this subcomponent focused heavily on public awareness surrounding pollution, coral disease, coral bleaching, and resource use. They also focused on collaborations that improved public outreach initiatives and ways to improve scientific communication. For example, consider this representative quote from the Technical Advisory Committee:

> "We have an idea of what reefs should look like and then the reality of [its condition]. The general public might not know what is wrong with the reefs. What hasn't happened [...] is people realizing that the state of the reefs is due to their actions. We have a huge challenge, because we need the public to realize what they are doing."

Cultural Heritage included any mention of the shared importance of the Florida Reef Tract or its value for future generations. This subcomponent looked very similar across both organizations, where preserving the Florida Reef Tract was the primary concern. Both organizations also mentioned the historical value of the resource as a source of livelihood. The FKNMS often mentioned access to shipwrecks as a form of cultural heritage. Interview respondents mentioned a desire for their children to be able to have access to the reef. For example, consider this quote from Interview Respondent 11:

> "You know, are we there yet? Have we fully reversed [the damage]? No, but they're certainly closer to getting there, and you know, will the reef be back as it was in the 1940s and 1950s during my lifetime? Nope, it won't, [but] hopefully for my grandkids. There's gotta be some sort of hope for the future."

In contrast, SEFCRI mentioned a desire for the public to understand their connection to the reef and become better stewards. For example, consider this quote from the news data, "Today, more than ever, it is vital that [everyone] continue to learn how to strike a balance between enjoying Florida's precious resources in the sea and ensuring that they remain vibrant and thrive for generations to come."

Lastly, *Homogenization of Values* included any mention of what is collectively deemed acceptable in conservation, including shared beliefs, knowledge, and values. For the FKNMS, this subcomponent often emphasized stakeholder involvement, like encouraging fishermen to collectively see the good in the sanctuary. Speakers also mentioned making regulations more widely known. For example, one quote from the Sanctuary Advisory Council meeting minutes demonstrates how public access to council meetings helps encourage shared beliefs:

> "[The public attendee] hadn't realized how much impact the boats such as his and others put on these low water areas, especially when moving through the narrow channels. He always assumed that if the boat did not run aground that it didn't cause damage. Now, he understands that constant wake from vessels can actually have a larger impact. He agrees that each area should be looked at separately and each area should have its own set of rules."

For SEFCRI, Homogenization of Values was discussed in relation to topics like collaborative efforts towards management, increasing public awareness, creating a community around reef resilience, and improving public perceptions of management. For example, consider this quote from SEFCRI Interview Respondent 4:

> "You know, this comes back to your question, 'how does the evolution of management practices change?' Fifty years ago everybody was happy and nobody wanted the government involved in anything. And now we're getting to the point where there's stuff happening that people can't fix on their own [...] So, regardless of politics, regardless of whether they're left or right, or whether they believe in government, or they don't believe in government, [people] have got to take a position where they want the government involved."

(7.4) Issue Framing

The fourth concept of my theoretical frame is *Issue Framing,* which includes any information about whether an institution adequately considers both anthropogenic impacts and novel solutions when managing a novel ecosystem. In other words, is the organization properly considering the ecological context before making management decisions? This concept includes six subcomponents: 1) *New/Changing Objectives;* 2) *Novel Solutions;* 3) *New Species Interactions;* 4) *New Ecosystem Functionality;* 5) *New Understanding;* and *6) Anthropogenic*

Effects. (Table 2.4). Six representative quotes, three from each organization, describe instances of *Issue Framing* in the data collected separately from news, meeting minutes, and interviews. These quotes are displayed in the table below (Table 9).

Table 9. Examples of Issue Framing from the data.

Issue Framing	
News	
FKNMS	"NOAA scientists have found that pressure from increasing coastal populations, ship and boat groundings, marine debris, poaching, and climate change are critically threatening the health of the Florida Keys ecosystem. Many historically abundant marine resources such as green sea turtles and coral habitat continue to be at risk with low rates of recovery." - Targeted News Source
SEFCRI	"The research team's project, funded by the Florida Department of Environmental Protection through the Southeast Florida Coral Reef Initiative, aims to identify the chain of causality land-based pollutants have rendered on the responses of reef-building coral and the health of coral reef communities in the South Florida Watershed." - Newspaper, University Wire
Meeting Minutes	
FKNMS	"People should not be 'prisoners' to only what is known here. The world has changed and is changing in terms of what people are trying to do and what is happening to systems everywhere. There is a lot of information on this topic, the ecosystem is a different place today." - Director, Office of National Marine Sanctuaries
SEFCRI	"I want to make sure that we emphasize that the most direct proximate trigger seems to be heat stress. Right? We had dramatic heat stress in the summer of '14 when this kicked off and we know from a lot of different places and reports that disease outbreaks closely follow heat stress events. That seems to be the most obvious proximate trigger. You've got a disturbed system and that makes it more potent perhaps but the heat stress has been extreme and persistent." - Researcher, NOAA Southeast Fisheries Science Center
Interviews	
FKNMS	"You know, I think there obviously could be more support with cleaning up the water and maintaining better water quality, especially off South Florida, and just as a society as a whole addressing climate change and the need to have more immediate action today." - Interview Respondent 1, Sanctuary Advisory Council

SEFCRI	"I don't know that conditions will ever be ideal again. I don't think there's any going back to the way things were because the Keys, Miami Dade, and Broward, they're not all the same as they were in the 1970's. The Keys may be a little better, because the majority of them are off septic now—they're all on a sewer system—but all the other areas... there's no returning, there will never be a pristine ecosystem ever again. The Reefs are in their new normal now, essentially." - Interview Respondent 12, Technical Advisory Committee

Issue framing addresses whether an organization properly considers the ecological context before making management decisions. For example, are things like novel species compositions or novel interactions being considered as parts of the novel ecosystem context, or are previous baselines being used that may no longer be relevant? My qualitative results show that both organizations considered relevant anthropogenic threats. Issue framing is where some of the most insightful results appeared, which indicated the presence of novel characteristics requiring adaptive approaches to management. For example, multiple interview respondents stated that the Florida Reef Tract has experienced irreversible changes. Consider the following quote from the Director of the Office of National Marine Sanctuaries:

"The world has changed and is changing in terms of what people are trying to do and what is happening to [ecosystems] everywhere. There is a lot of information on this topic. The [Florida Reef Tract] is a different place today. It is important to think about the long term picture. Thirty years ago it would have been hard to know that the ecosystem would deteriorate so much even when it was being managed. This is why it is so important to think differently in [the Florida Keys National Marine Sanctuary]."

Topics related to Issue Framing were similar between the SEFCRI and FKNMS data. Both institutions acknowledged major stressors such as climate change, coral bleaching, ocean acidification, water quality, coral disease, new species interactions, coastal development, and shifting baselines. All such stressors and issues were classified as requiring novel solutions. Additionally, interview data from both organizations suggests there is a strong and growing sentiment that both systems are novel ecosystems. For example, take this quote from an interview with an FKNMS affiliated researcher:

"Since I started my PhD and you can see the community changing on our reefs [...] after stony coral tissue loss disease went through, it's 100% a novel ecosystem in that it's relatively difficult

to find living scleractinian corals… it's not only architecturally [different] in terms of coral cover, but also the [fish and invertebrate] community has changed dramatically […] Hydrodynamically, biologically, ecologically; the ecosystem is absolutely one that is novel." - Interview Respondent 14

A similar data point from SEFCRI's Technical Advisory Committee demonstrates the same perception:

"I don't know that conditions will ever be ideal again. I don't think there's any going back to the way things were because the Keys, Miami Dade and Broward, they're not all the same as they were in the 1970s. The Keys may be a little better, because the majority of them are off septic now, they're all on a sewer system, but all the other areas there's not - there's no returning, [there] will never be a pristine ecosystem ever again. The Reefs are in their new normal now." - Interview Respondent 12

Both institutions seemed to acknowledge the same threats and the same needs to manage these threats via conventional management strategies. For example, both organizations often mentioned Stony Coral Tissue Loss Disease and discussed novel solutions, such as applying antibiotic-infused paste to halt the spread or instituting quarantine measures for divers.

To help further explain these findings for SEFCRI and the FKNMS and provide additional insight, I break down Issue Framing further by each of its six subcomponents and compare them across both organizations using representative quotes, beginning with *New/Changing Objectives*.

New/Changing Objectives involved any mention of new goals or objectives related to conservation. For the FKNMS, this subcomponent appeared in relation to changes to existing management plans, such as new protections for fish spawning aggregations and, in some cases, mentioned adaptation to anthropogenic threats. For example, consider this quote from the Director of the Office of National Marine Sanctuaries in the news data:

"The discussions today are about the importance of adaptation to change. Old ideas might not fit or work today or in the future and everyone must adapt to meet the changing conditions of the world. People are looking to the Keys for leadership on marine management issues [...]"

It also appeared in relation to considering the available capacity of reef sites for tourism and recreation, for example consider this quote from the Sanctuary Advisory Council meeting minutes:

> "However, what was made clear by the Advisory Council, partner agencies, and the public is the need to find better ways to address capacity issues at popular sites. The sanctuary is strengthening [outreach programs] and will work more effectively with commercial operators to reduce impacts to the fragile marine environment."

For SEFCRI, New/Changing Objectives was often mentioned in relation to new project proposals and adapting to the emerging threats to the Florida Reef Tract. For example, consider this quote from Interview Respondent 12:

> "I think that the issue of [climate change] is not just a separate goal, dealing with climate change is spread out through all of our goals and work in our organization at this point. There has been an evolving awareness and understanding of how to incorporate climate work."

Novel Solutions involved any mention of new ways or approaches to solving problems. This subcomponent was very similar to New/Changing Objectives and was used somewhat interchangeably because often, a new solution involved changing underlying management objectives to meet new goals. For the FKNMS, Novel Solutions included expanding habitat protections, new grant proposals, creating artificial reefs, and implementing restoration initiatives like the FKNMS' Mission Iconic Reefs, which is a massive undertaking to restore historically iconic reefs in the Florida Keys. For example, consider this quote about Novel Solutions from the Sanctuary Advisory Council meeting minutes:

> "[Marine Protected Areas] can provide a tool for mitigating climate change to avoid cascading ecological impacts due to species specific reactions to changing conditions. By creating population buffers, protecting [populations] and genetic diversity, facilitating shifts in species ranges, strengthening ecosystem connectivity, and monitoring [important] sites, marine protected areas can provide resource managers with a tool to mitigate [climate change]."

For SEFCRI, Novel Solutions included discussion about what new approaches to management might be effective. These included artificial reefs, possible restoration initiatives, improving genetic variation in coral species, and adopting more conservative baseline targets for reef health. For example, consider this quote from a discussion in the Technical Advisory Committee meeting minutes, "I'd suggest we adopt much lower values that speak to an environment that supports coral reefs, not the coral reef community remnants we have today."

New Species Interactions involved any mention of specific species interacting in new ways. For the FKNMS, this was almost exclusively related to invasive species, primarily the Lionfish. However, some speakers mentioned the lack of apex predators and new species compositions. For example, consider this quote from Interview Respondent 1:

> "But, I would say, once you get down into the keys, [...] without that foundational coral there, you're just not getting that biodiversity [...] I imagine that's affecting a lot of different other organisms, you know from the bacteria that live there, all the way [up] to [the] apex predators that are [now] kind of rare."

For SEFCRI, discussion surrounding New Species Interactions often involved the effects of coral disease, the possibility of corals becoming functionally extinct (i.e., becoming so rare they cannot reproduce), and the disappearance of the long-spined sea urchin. For example, consider this quote from a researcher in the Technical Advisory Council meeting minutes data:

> "I have been doing a lot of work in the Caribbean and the biggest thing that has happened is when the spiny sea urchin died. If you go to places in the Caribbean where they have come back, no matter how nutrified, overfished, or how destroyed the environment is, where there is Diadema, the reef is actually growing. Corals are a lot more robust than you think they are. I think we need to start investigating how to bring back Diadema into these waters."

New Ecosystem Functionality involved any mention of collective changes to the entire ecosystem. The FKNMS mentioned New Ecosystem Functionality in relation to the unprecedented state of the Florida Reef Tract and the destruction it has faced. The need for restoration initiatives and new artificial reef habitat were also common topics, as well as water quality and climate change. For example, consider this quote from the news data:

"NOAA scientists have found that pressure from increasing coastal populations, ship and boat groundings, marine debris, poaching, and climate change are critically threatening the health of the Florida Keys ecosystem. Many historically abundant marine resources such as green sea turtles and coral habitat continue to be at risk with low rates of recovery."

For SEFCRI, New Ecosystem Functionality was heavily centered around coral disease and its long-term impacts on the reef tract. However, interview respondents also mentioned the impacts that large coastal population centers in the SEFCRI region are having on the marine environment. For example, consider this quote from Interview Respondent 6:

"The coral reef system is evolving, it is being watched by a lot of people, there's a lot of protection going on, but it's been beaten up by the population increases that we have here—more drainage, more sewer, more boats. There's too many people in one small area."

New Understanding involved any mention of new ideas, theories, or knowledge that has arisen as a result of novel conditions. The FKNMS mentioned New Understanding for topics like the importance of protecting the Florida Everglades, shallow-water habitats, and spawning aggregations. This information, including new science and reports, was then used to support changes to regulations. For example, consider this quote from a resource manager in the news data:

"It is estimated that more than 90 percent of these corals have been lost because of disease, coral bleaching, and tropical storm damage," according to the Fisheries Service. "[The] overall deterioration of coral reef habitats appears to be compromising the species' ability to reproduce, making this proposed designation even more important."

In contrast, SEFCRI mentioned New Understanding more often, especially in relation to newly completed surveys and data collection, which contributed new knowledge about the northern reaches of the Florida Reef Tract. However, coral disease was also a big topic, generating discussion and new insights into disease dispersal and treatment. For instance, consider this quote from the Technical Advisory Committee Meeting Minutes:

"[We] also found that there is some impact to zooxanthellae [...] is the pathogen affecting the [symbiotic microalgae] or the corals? On an inshore and outshore monitoring site, the inshore bleached heavily and the disease was stopped, the outshore did not bleach and the disease continued."

Anthropogenic Effects involved any mention of human-caused disturbance to the ecosystem. The FKNMS often mentioned Anthropogenic Effects in terms of cause and effect. For example, threats to shallow-water ecosystems generated discussion about increasing boating regulations to protect seagrass beds. In another instance, lobster traps damaging reef areas generated discussion about new regulations to reduce trapping close to sensitive areas. The Sanctuary Advisory Council also mentioned a wide variety of anthropogenic threats while considering new recommendations or discussing the status of the Florida Reef Tract. For example, in one Sanctuary Advisory Council meeting, a member brought up the impacts of increasing tourism and recreation:

"Whoever thought we would see guys with [water] jetpacks flying around, and kiteboarders?" asked [a Sanctuary Advisory Council member] presenting the findings of the Shallow Water Wildlife and Habitat Protection Working Group. "We didn't think about this five years ago," [the representative] said. "We've got party zones, jetski tours and eco-tour groups." [The representative said] he was "blown away" by the effect that boating could have on critical bird-nesting habitats."

For SEFCRI, Anthropogenic Effects often mentioned the possible origins of Stony Coral Tissue Loss Disease, population growth, coastal development, sources of pollution, water quality, and the compounding nature of these threats. For example, consider this quote from Interview Respondent 9:

"Certainly the most overriding thing that is impacting everything in our coastal counties is terribly impaired water quality, but that's coupled with having so many people close to the reef. The corals can't breathe because the water is bad, but also you have people pummeling them. Our over use and our blatant disregard for water quality is imperiling everything […] In terms of resilience, if coral reefs were healthy, they probably could have fought off a lot of disease and other issues. Is this something that would have affected them 100 years ago when they were healthy? Or are these effects because [humans] have beaten them to a pulp?"

(7.5) Power and Authority

The final concept of the theoretical framework, *Power and Authority,* is defined as information about whether an institution is well-organized, capable, respected, and willing to consider necessary changes. This concept includes six subcomponents: (1) *Clearly Defined Roles & Responsibilities;* (2) *Regulatory Enforcement; Compliance;* (3) *Institutional Changes;* (4) *Procedural Changes;* and (5) *Perceived Legitimacy.* (Table 2.5). Six representative quotes, three from each organization, describe instances of *Framing* in the data collected separately from news, meeting minutes, and interviews. These quotes are displayed in the table below (Table 10).

Table 10. Examples of Power and Authority from the data.

Power and Authority	
News	
FKNMS	"Stakeholder support for management strategies and regulations of the Florida Keys National Marine Sanctuary grew dramatically among key user groups over a 10-year period, according to a study conducted by researchers from NOAA, the University of Miami's Rosenstiel School of Marine and Atmospheric Science, and Thomas J. Murray and Associates. The increase in support is particularly significant among commercial fishermen, the majority of whom were against the creation of the sanctuary." - Targeted News Service
SEFCRI	"The project [developed by the Southeast Florida Coral Reef Initiative (SEFCRI) Maritime Industry and Coastal Construction Impacts team] has identified administrative opportunities for agencies to evaluate and encourage more effective coral reef permitting in Florida. 'We are developing scientific and legal support with our partners for this initiative,' said [a source]" - Targeted News Source
Meeting Minutes	
FKNMS	"Based on the success of the Florida Keys advisory council, each of the other sanctuary sites established advisory councils. The advisory council process has become a trademark of the sanctuary program and represents a fundamentally different way of working in which top-down government allows for bottom-up input." - Director, Office of National Marine Sanctuaries

SEFCRI	"So, the leadership will probably go to the Florida Department of Environmental Protection (DEP). But one of the things with this that I have alluded to is: because we have such a large area, the field logistics are going to be a team effort. As it moves into the future it is going to continue to be a team effort with the leadership role assumed by the DEP." - Coastal Ecologist, NOAA
Interviews	
FKNMS	"There's certainly pushback from the community about certain aspects of the plan and certain members of the constituents that aren't happy with some of the proposed changes, but as a whole, I think the community embraces the conservation of a critical resource that the county relies on being healthy in order to have a foundational economy for fisheries and eco-tourism and visitor use. So, I think there's a lot of understanding, respect, and appreciation for the sanctuary." - Interview Respondent 1, Sanctuary Advisory Council
SEFCRI	"In a way it's getting harder and harder to accomplish [...] We're just learning about spawning, and what the wildlife is doing, and how the wildlife interacts with their own habitat. Having that science and knowledge should inform our policy and all the work that I think that these agencies and nonprofits are prioritizing. When you look at the different players for the Florida Reef Tract you're swimming in acronym soup, it's difficult." - Interview Respondent 13, Technical Advisory Committee

Power and Authority was starkly different between the two institutions. Data from the FKNMS defined Power and Authority as *Regulatory Enforcement* and *Procedural Changes*. Much like Administrative Competence, these aspects focused on direct actions to enforce laws and regulations and ensure compliance within protected areas. For example, a representative from the Florida Fish and Wildlife Conservation Commission's Division of Law Enforcement had this to say:

> "FWC had seven offshore patrols out to the Tortugas, Pulley Ridge and other locations. They have just obtained one more offshore patrol boat. So, now five boats are going out to the Tortugas now. Every time they go out there, they [enforce rules on somebody breaking them]. The goal is to make the stops and to find people in compliance, but they are not finding that to be true. This points to the notion that poaching may be taking place when the patrols are not there. They will continue patrolling the area and making cases."

This quote, like many others, points to the increased enforcement capabilities of the FKNMS as a federal institution and highlights how the FKNMS can take direct action against any person(s) violating regulations within the sanctuary.

On the other hand, within the SEFCRI data, there was not as much regulatory implementation or enforcement. Instead, SEFCRI focused on the leadership roles of various parts of their administration, and once again, much like was the case with Administrative Competence, Power and Authority tended to focus more heavily on adequate preparation. For example, the potential for new marine zoning, forms of cooperative management, and improvements via institutional changes dominated the data. In other words, SEFCRI placed heavy importance on the ability to implement effective management when the resources become available. This is not to say that they are not participating in active management, only that they emphasize having robust data, plans, and mechanisms in place to act quickly. A representative data point that highlights SEFCRI's preparation for management actions, rules, and regulations can be found in the following quote from SEFCRI's Technical Advisory Committee:

> "What happens to recommendations? [It's] not a management process, it is identifying recommendations that the committee will make to the SEFCRI chair and those will be forwarded to appropriate management agencies [...] Those will be brought forward and then have to go through their particular rule making processes. [The] Committee will provide recommendations to appropriate management agencies [who] will decide what to take forward into their work plans and rule-making process."

To help further explain these findings for SEFCRI and the FKNMS and provide additional insight, I break down the concept Power and Authority further by each of its six subcomponents and compare them across both organizations using representative quotes, beginning with *Clearly Defined Roles and Responsibilities.*

Clearly Defined Roles and Responsibilities included any mention of the definition, clarity, and acceptance of specific roles and responsibilities. For the FKNMS, this sometimes included instances of strong scientific leadership, like within NOAA and the Sanctuary Advisory Council, but also included agencies like the Florida Fish and Wildlife Conservation Commission or the United States Coast Guard, which are responsible for law enforcement. For example, take this quote from the Sanctuary Advisory Council meeting minutes, "NOAA Fisheries has reorganized its protected resources division to form a new coral branch that will help address the

heavy Endangered Species Act (ESA) consultation backlog and also lead other coral-related ESA efforts." Alternatively, SEFCRI mentioned leadership roles like those of the Florida Department of Environmental Protection and other collaborating partners, such as universities. For instance, consider this quote from the Technical Advisory Committee meeting minutes:

> "So, the leadership will probably go to the Florida Department of Environmental (DEP) Protection. But one of the things with this that I have alluded to is, because we have such a large area, the field logistics are going to be a team effort. As it moves in the future it is going to continue to be a team effort with the leadership role assumed by the DEP."

Regulatory Enforcement included any mention of new or existing regulations which are actively enforced. For SEFCRI, mentions of Regulatory Enforcement were limited, as they have less rule-making authority and enforcement capabilities; however, there were some instances where SEFCRI effectively supported broad regulatory actions at the state and federal level. For example, consider this quote from the SEFCRI news data:

> "SEFCRI successfully pushed for the Coral Reef Conservation Act of 2009, which assesses penalties against boaters who anchor or run aground on coral reefs. Currently, two species found in local waters, elkhorn and staghorn [corals], are listed as threatened under the federal Endangered Species Act."

However, the FKNMS often mentioned Regulatory Enforcement as a means to achieve more effective resource management. Regulations were mentioned in connection with topics like user fees, boating, fisheries, diving, endangered species, and migratory species. For example, consider this quote from a representative in the Sanctuary Advisory Council meeting minutes data:

> "Last week, NOAA Fisheries published a new rule that will create a year-round boundary for the Gulf and Atlantic migratory groups of king mackerel at the Miami-Dade/Monroe County line. When the rule takes effect in mid-May, Monroe County will become part of the Gulf Southern Zone year-round, the recreational bag limit will increase to 3 fish per person per day, and the commercial fishery is expected to re-open with increased catch quotas."

Compliance included any mention of resource users complying with new or existing regulations. For the FKNMS, Compliance was often mentioned in conjunction with public

awareness and public cooperation. For example, consider this quote from the news data, "[the FKNMS] further suggests additional efforts are necessary to support sustained management efforts, and increase regulatory compliance and community engagement to address those challenges." For SEFCRI, Compliance was rarely mentioned and only brought up as a general concern. For example, consider this brief quote from the SEFCRI meeting minutes, "enforcement and compliance seem to be a problem."

Institutional Changes included any mention of instances where the redistribution of power or changes to overarching institutional values could be beneficial. For the FKNMS, this subcomponent was discussed in relation to new proposals, like expanding no-take zones, the Restoration Blueprint (an environmental impact statement intended to inform the Management Plan rewrite), and instances where changes to the internal structure of the Sanctuary were announced. For example, consider this quote from the FKNMS news data:

> "Under a reorganization plan working its way through the National Oceanic and Atmospheric Administration, [the superintendent] would be named one of four [regional chiefs] for the National Marine Sanctuary Program. [A replacement], is slated to be named manager for the 2,900-square-mile Keys sanctuary."

For SEFCRI, many instances of Institutional Changes were limited only to discussion, that is, changes that had not been implemented, but their necessity was documented in conversation. However, there were some changes mentioned where leadership roles transitioned and programs evolved. For example, take this quote from an announcement in the meeting minutes data:

> "2018 marked the formal transition of the coordination and management of the [Disturbance and Response Monitoring program (DRM)] to the [Florida Fish and Wildlife Conservation Commission]. The structure of the DRM program will remain the same, but there will be a new website, data entry system, report generator, database format, and quality assurance procedures. New data fields were also added to the DRM methodology to better document the unprecedented coral disease outbreak."

Overall, SEFCRI's Institutional Changes were similar to the FKNMS. However, they were more-so limited to scenarios where possible institutional changes were identified which could increase reef resilience.

Procedural Changes included any mention of new procedures for practice or the reallocation of responsibilities. For the FKNMS, Procedural Changes appeared under similar circumstances as Institutional Changes. However, a quote from the news data highlights a difference:

> "At its [meeting] in Key West, the Sanctuary Advisory Council asked staff to make sure the Florida Fish and Wildlife Conservation Commission knows the sanctuary desires the opportunity to provide formal comment [...] on any action that could result in the establishment of a pilot program on the legislation of the use of artificial habitats in Keys waters."

In some cases, like the above quote, Procedural Changes were subtle, where simply relaying new information about 'who' would be involved in a process and 'how' was considered a procedural change. For SEFCRI, Procedural Changes were also usually small adjustments to day-to-day activities. For example, consider this quote from the meeting minutes data, which discusses the importance of changing procedures to better include the fishing community:

> The Florida Department of Environmental Protection [gave] the idea of creating a process that was more balanced or fishing focused [...] in order to regain more constructive engagement. Also [...] suggestions [were made] to modify the logistics. Based on these findings, the Florida Department of Environmental Protection developed a set of recommendations for a new engagement approach.

Finally, *Perceived Legitimacy* included any mention of respect for and appreciation of existing authority. In the case of SEFCRI, Perceived Legitimacy was mentioned concerning using cooperation in the actor-network to meet management objectives and maintain public support. Consider this representative quote from Interview Respondent 7, "Public perceptions were really bad for a really long time with SEFCRI (same thing that happened with the FKNMS), but today that has totally changed. Having more transparency and public support is essential." For the FKNMS, Perceived Legitimacy often came in the form of negative comments

and criticisms, where the general public and stakeholders felt that the government was overreaching and limiting their access to resources. However, there were many instances where Perceived Legitimacy seemed to improve over time as the Sanctuary earned the public's trust. For example, consider this quote from one of the stakeholders on the Sanctuary Advisory Council, "Management does listen to us, and the council really makes a difference in what goes on. It has brightened my opinion of how things work at the government level."

(7.6) Iterative Learning

Before moving on, it is important to also discuss the presence of iterative learning in the data, which was used as a way to assess institutional progress in adaptive governance. I added iterative learning to my revised theoretical framework prior to data collection due to its importance in my analysis. The table below (Table 11) shows examples of *single, double,* and *triple-loop learning*, as well as the reasoning behind each example. First, single-loop learning data are defined as day-to-day management actions that demonstrate incremental improvements towards meeting management goals (Pahl-Wostl, 2015). Second, double-loop learning data are defined as instances where guiding assumptions are questioned in relation to how management goals can be achieved, leading to the development of new management approaches (Pahl-Wostl, 2015). And third, triple-loop learning data are defined as the overhaul of regulatory frameworks or fundamental changes in values or ideologies that recognize current systems as ineffective. Triple-loop learning often results in new actors joining networks, changing power structures, and introducing new regulatory frameworks through iterative, adaptive governance (Pahl-Wostl, 2015). In this way, institutions can learn over time and incorporate new strategies which propel their management towards contemporary approaches that are best suited to combat the threats of the Anthropocene.

Table 11. Examples of iterative learning from the data, including the rationale.

Single-loop Learning	Reasoning

FKNMS	"It's mandatory that [a draft environmental impact statement] contains a no-change alternative, It seems understandable and wise to have an alternative on the other end with larger areas of marine reserves." - Researcher, Targeted News Source	In a structured decision making process, a "no-change" alternative is standard practice.
SEFCRI	"I think in the theory of brainstorming, there is no such thing as a bad idea and I am absorbing this as my first TAC meeting. One way that I manage things is through reverse engineering, what are the actionable items, what are the things that you can do to make a difference, and then I have tiers, there might be stuff that is real simple, like putting out a fire, or big long term plans as far as that goes. So I would look at what the actionable items are and then what can we do as far as monitoring to get to that spot." - Representative, Technical Advisory Committee	Prioritizing actionable items is a great way to examine alternatives and triage management needs. However, in this case, monitoring appears to be a "day-to-day" management action that is not necessarily questioning any guiding assumptions.
	Double-loop Learning	**Reasoning**
FKNMS	"After being updated on available information, the working group on Friday is scheduled to use the Dry Tortugas as the basis for a dry-run exercise to "consider how the group can use the available data to explore options and develop recommendations." - Deputy Sanctuary Superintendent	By using the existing data to explore new management options and recommendations, an iterative process has begun which questions the guiding assumptions.
SEFCRI	"I have some quick things. The first one is observing your data. There seems to be a higher disease prevalence in Miami-Dade and Broward counties than the rest of the tract. Is that something that you have seen throughout the years? [...] It's important to share results, it's important to tell the whole story. When you look at the whole story, you can look at management positions that can help us deal with the different threats that we are observing out there." - Representative, Florida Department of Environmental Protection Coral Reef Conservation Program	This is a clear instance of reflection on past management actions and their inclusion in new management decision-making.
	Triple-loop Learning	**Reasoning**
FKNMS	"The discussions today are about the importance of adaptation to change. Old ideas might not fit or work today or in the future and everyone must adapt to meet the changing conditions of the world. People are looking to the Keys for leadership on marine management issues because of the long-history of experience in the Keys and because the Keys are experiencing change. The question becomes how to sustain this already degraded ecosystem in view of increasing pressures while also maintaining the economy of the Keys. - Director, Office of National Marine Sanctuaries	The speaker clearly mentions an adaptive process of iterative learning being successfully implemented to address contemporary issues.

SEFCRI	"Due to the disease event, the conversations that we are having are different. There are elements that are more open to conversations and that kind of change means that we need to adapt. If there is an opportunity to have that conversation again, we should not discard that opportunity because 30-40 years ago we failed to make that connection as a body." - Representative, Florida Department of Environmental Protection, Coral Reef Conservation Program	The speaker mentions learning from past conditions and environmental changes as a cause for imperative management adaptation to prevent failure in the future.

For both organizations, single-loop learning was mentioned the most often, double-loop the second-most, and triple-loop third. While this was expected, the incidence rates of only single and triple-loop learning were statistically significantly different, a fact I previously discussed in my quantitative findings (Table 5). Below I explore the differences between each organization as they pertain to each type of iterative learning.

For SEFCRI, single-loop learning occurred less often than for the FKNMS. However, for SEFCRI, single-loop learning often mentioned the development of new understanding, such as discovering new disease vectors for Stony Coral Tissue Loss Disease or how the age of corals might impact stress tolerance. Essentially, single-loop learning included small or incremental additions to the base of knowledge. Brainstorming was also common in these instances such as coming up with new ideas for the Local Action Strategy. These ideas included suggestions like incorporating green-infrastructure projects into city planning, restricting the use of pesticides on lawns and farms to protect the reef, or eliminating beach renourishment programs which dredge the substrate offshore. For the FKNMS, single-loop learning often centered on incremental changes to regulations, rules, zoning, and leadership. For instance, instituting user fees to generate funds for conservation, searching for new areas to make into Sanctuary Preservation Areas, or rotating positions on the Sanctuary Advisory Council were all small changes that reflected single-loop learning in the FKNMS case.

Double-loop learning is the first indicator of substantial iterative change. For the FKNMS, double-loop learning included conducting reviews of current management projects, reworking the management plan (usually tied to the development of the Restoration Blueprint

and the Management Plan rewrite), redefining roles and responsibilities, new research, new projects, and clear cases of evolution in management. For example, consider this quote from the Sanctuary Deputy Superintendent:

> "We are continuing to work on the [Restoration Blueprint], which includes developing all the environmental and economic analyses for each of the possible alternatives [...] we need to ensure that we accurately reflect the recommendations of the Sanctuary Advisory Council."

This is a clear instance where guiding assumptions were questioned using a process of structured decision-making to incorporate recommendations and achieve best management outcomes. In most cases, instances of double-loop learning for the FKNMS were tied to the Coral Reef Conservation Program, the initial management plan from 1997, monitoring and restoration, the Draft Environmental Impact Statement, and new boating regulations.

For SEFCRI, double-loop learning often included proposing new Local Action Strategy projects (not just brainstorming for them), novel and actionable options, like making modeling, mapping, and data collection methodologies more effective, and cooperation, such as increasing transparency among actors and communicating results. For example, consider this quote from a representative of the Florida Department of Environmental Protection's Coral Reef Conservation Program:

> "Science, through monitoring, has contributed to the conversation of continuing science funding […] These things are never happening in a vacuum and are always interconnected [...] We have funded different monitoring efforts throughout the years and communicated the results [which] have allowed us to [...] prove the need to keep looking into these resources toward a better management of them."

This is also an instance where management is being improved through an iterative, learning approach. However, in this case the learning is being channeled into increased funding for conservation, a topic which was often cited in the SEFCRI interview data. For SEFCRI, most instances of double-loop learning were tied to general improvements in the quality of the

northern Florida Reef Tract, the roles of the Technical Advisory Committee, water quality, coral disease, and regional modeling.

Finally, for triple-loop learning (the ultimate objective of the iterative learning process), SEFCRI included extremely clear messaging about "shifting paradigms," where the usual approach to management is being replaced by a new and different way of thinking, redefining the overarching priorities, and in some cases specifically mentioning the need for adaptive governance to address and incorporate the concepts for novel ecosystem management. For example, take this representative quote from a Technical Advisory Committee representative:

> "[...] We need to shift our mental model because we are under the assumption that everyone operates how we do. We get facts, we understand things, and we automatically know what we need to do. Education and knowledge is great, but it doesn't change the will to do something unless you target it. If you look at the barriers that are preventing it. It is really changing how we are thinking about things and understanding what is going on to create change and get action."

As a second example, consider this quote, also from a representative on the Technical Advisory Committee:

> "We didn't know a lot about the reef at all when I first started, and we learned a lot. I think you are absolutely right that we need that paradigm shift and we need it now [...] So, I think that the monitoring is important but what are the actionable items, and how do we get the linkage between the management, science, and people? When you get the folks involved, we can get some action done. I think folks are getting more aware and that is important because they can go to the legislature, and then start supporting you, because that is what it takes."

These are both clear instances of adaptive management which consider the breadth of the problem and propose actionable, revolutionary solutions which propel management over barriers that may inhibit novel ecosystem management.

The FKNMS also incorporated triple-loop learning to a greater degree than SEFCRI. Triple-loop learning often incorporated new funding opportunities, overhauls to their approach to ecosystem restoration, mentions of adaptive governance, and discussions about how the new

management plan would build on previous iterations. There were also instances where, like SEFCRI, reflection on the organization's strengths generated a self-awareness which emphasized adaptive management. For example, consider the following representative quote from the Director of the Office of National Marine Sanctuaries:

> "The advisory council process has become a trademark of the sanctuary program and represents a fundamentally different way of working in which top down government allows for bottom up input [...] The discussions today are about the importance of adaptation to change. Old ideas might not fit or work today or in the future and everyone must adapt to meet the changing conditions of the world. People are looking to the Keys for leadership on marine management issues because of the long-history of experience in the Keys and because the Keys are experiencing change. The question becomes how to sustain this already degraded ecosystem in view of increasing pressures while also maintaining the economy of the Keys."

While triple-loop learning was somewhat rare, these instances of triple-loop learning are both insightful and powerful, indicating that not only is learning happening within both organizations, but also that triple-loop learning is moving management forward.

In the next section I return to the criticisms within the interview and meetings minutes datasets for a closer look via qualitative analysis. This data reflects the most contemporary criticisms, which differ from those in the news data which sometimes reflected older perceptions.

(7.7) Criticisms: Conflicting Data in Interviews & Meeting Minutes

Returning to my criticisms data, while the aggregate data (Figure 3) showed more criticism for the FKNMS than SEFCRI, the opposite was true for the interview data, where SEFCRI was often the subject of more criticism than the FKNMS. The interview data was recorded in 2021 and reflects more current perceptions of each institution. Figure 4 shows total counts of the most heavily criticized concepts and their subcomponents within interviews. In my research, the interview data showed the most instances of criticisms for both organizations. The aggregate dataset includes information from 1996-2020, compared to the interview data which includes the contemporary perceptions from 2021.
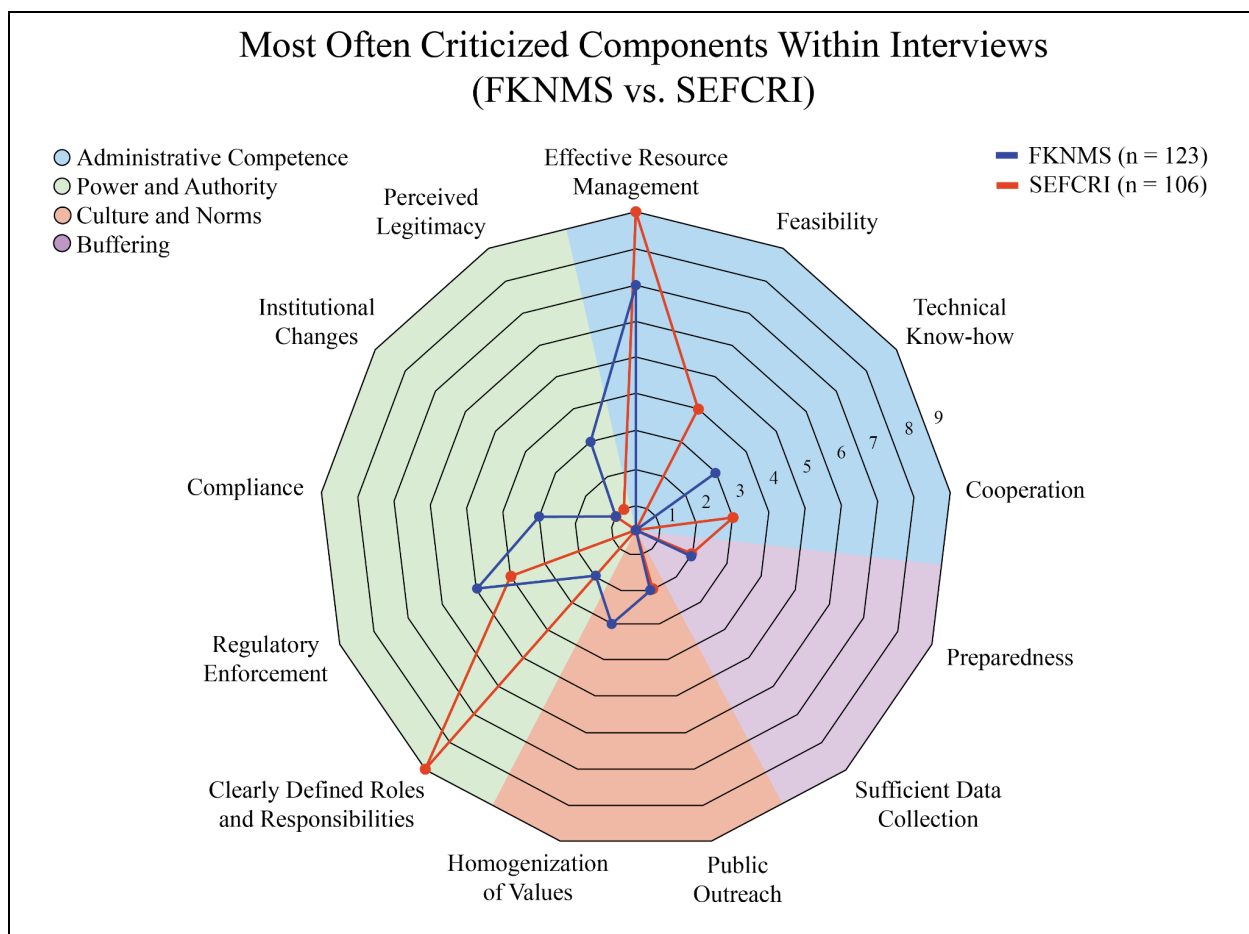
Figure 4. This chart depicts each institution's most heavily criticized subcomponents within the interview data. The subcomponents are overlaid on their appropriate concept. The numbers indicate the instances of each criticized subcomponent.

For SEFCRI, *Clearly Defined Roles and Responsibilities* and *Effective Resource Management* were equally criticized (both were criticized nine times in the interview data). Criticisms of Clearly Defined Roles and Responsibilities typically involved difficulty coordinating management across multiple actors and municipalities. For example, consider this quote from Interview Respondent 7 on the Technical Advisory Committee:

> "The Florida Department of Environmental Protection and the Florida Fish and Wildlife Conservation Commission used to be one entity, now one has water and the other has the animals[…] So, there is a lot of communication, but not as effective communication."

On the other hand, Effective Resource Management was usually criticized in relation to whether projects were actually completed and whether SEFCRI's initiatives were effective. For example, consider this quote from a member of the Technical Advisory Committee:

> "I look at what SEFCRI did with Our Florida Reefs, which is this huge initiative that developed all kinds of management actions, but really, a [small] percentage of it survives. It is almost as if [SEFCRI's] policy is, "we'll just throw in as much stuff as we possibly [can] in the [hope] that tiny bits survive."

In sum, most of the criticism for SEFCRI was related to *Clearly Defined Roles and Responsibilities* and *Effective Resource Management*. In other words, this means that ambiguous definitions for specific roles, and a lack of clarity for roles, was a point of criticism for SEFCRI. Also, stakeholders criticized that management actions were not always directly beneficial to conservation, a form of ineffective resource management.

In one way, the FKNMS criticisms were similar to those of SEFCRI. For the FKNMS, *Effective Resource Management* was also the most often criticized subcomponent (a total of seven instances). Criticisms of this subcomponent were often associated with not having enough protected areas or not generating or communicating enough results. For example, consider this quote from Interview Respondent 14:

> "The MPAs and the no-take zones and the special preservation areas [...] yeah, we got a whole bunch of them, and maybe maybe they cover 1% of the seafloor in the Sanctuary but [they are] so small and disparate that they're not meaningful protected areas."

However, *Regulatory Enforcement* was the second-most often criticized subcomponent (a total of 5 instances). This appeared in relation to public compliance with regulations and the ability of law enforcement officers to do their jobs effectively. For example, consider this quote from Interview Respondent 16, a member of the Sanctuary Advisory Council, "The law enforcement in the sanctuary is (and this is not about the individual law enforcement officers) [ineffective] I could go out there and break 90% of the rules, regulations, and laws and nobody would ever know it."

Overall, both *Effective Resource Management* and *Regulatory Enforcement* were among the most heavily criticized subcomponents. Criticisms of Effective Resource Management were discussed in conjunction with regulations, like those found in marine protected areas, and results, like the unclear dissemination of conservation successes. Additionally, criticisms of Regulatory Enforcement often talked about an inability to enforce laws and regulations across such an enormous area.

When comparing criticisms between SEFCRI and FKNMS, the sample sizes are too low to infer significance between a comparison of these counts. But, one can make note of the most frequent criticisms for SEFCRI: *Effective Resource Management* and *Clearly Defined Roles and Responsibilities*; juxtaposed with the two most frequent criticisms for FKNMS: *Effective Resource Management* and *Regulatory Enforcement*. These counts can serve as crude weights for the different subcomponents within the theoretical framework discussed by stakeholders.
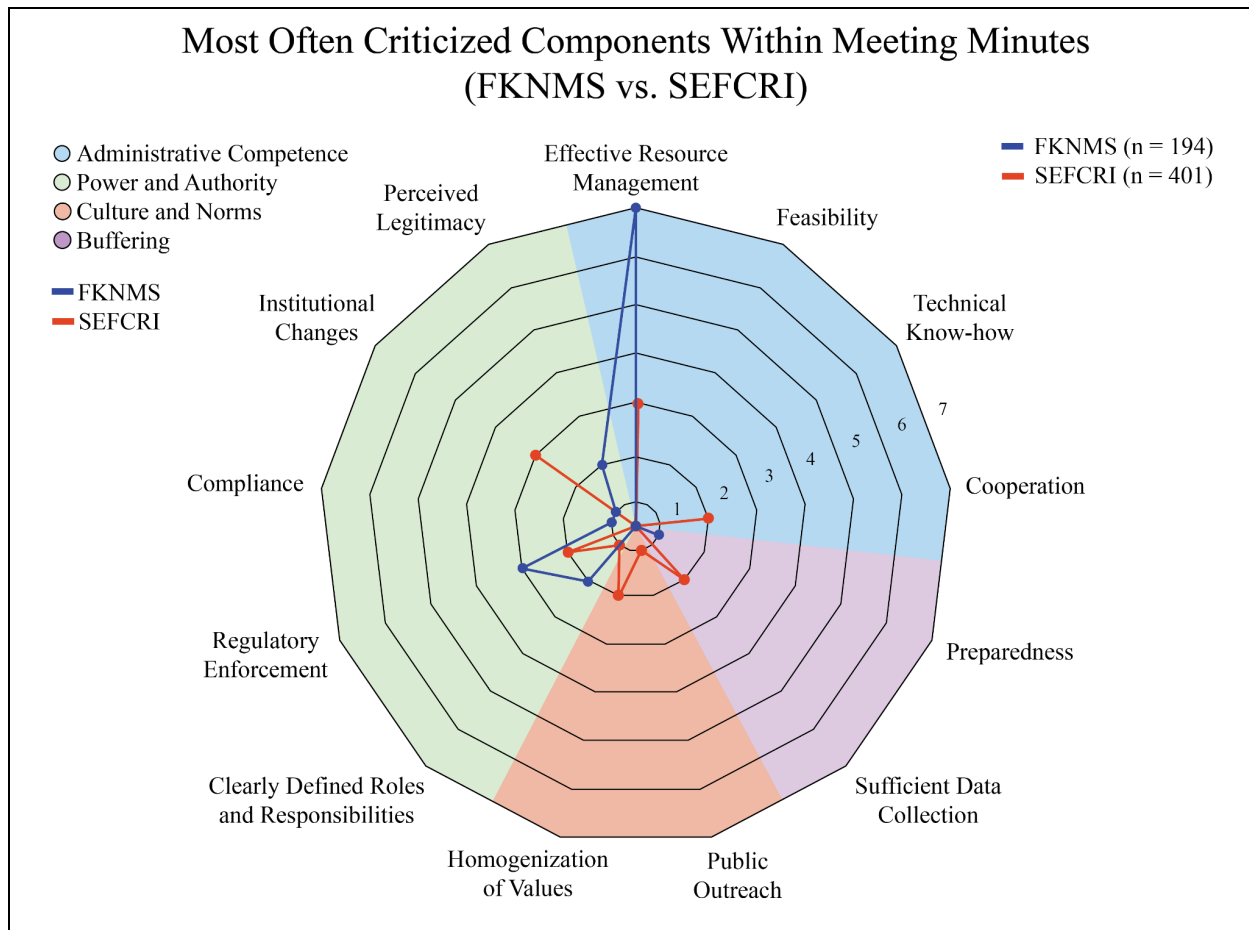
Figure 5. This chart depicts each institution's most heavily criticized subcomponents within the meeting minutes data. The subcomponents are overlaid on their appropriate concept. The numbers indicate the instances of each criticized subcomponent.

Analyzing counts of criticisms from the interview data provided some preliminary data as to how stakeholder views are changing because I was able to compare it to the meeting minutes data, which has been collected over a longer period of time. As a reminder, the meeting minutes data were collected from the transcripts of the formal FKNMS Sanctuary Advisory Council meetings and SEFCRI's Technical Advisory Committee meetings. Figure 5 shows criticisms broken down by subcomponents into the five categories of the theoretical framework from the meeting minutes from both organizations. In that data, which goes back to 2015, the FKNMS meeting minutes had the same most commonly criticized concept as in interview data: *Effective Resource Management*. Effective Resource Management was criticized 7 times and included

topics such as ineffective regulations, a need for better licensing, and lingering pollution. For example, consider this quote from the United States Coast Guard in the meeting minutes data:

> "In April 2016, 22 vessels were identified and mapped; not everyone meets USCG criteria for removal using pollution funds. In some cases, the vessel has fallen apart and only trash is left behind. Trash is not eligible for pollution funds unless it is a container with oil, etc. It's very hard to justify a strategy to remove just trash."

SEFCRI's most commonly criticized subcomponents in meeting minutes data included a tie between *Effective Resource Management* and *Institutional Changes* (compared to the interview data where the most common subcomponents were *Effective Resource Management* and *Clearly Defined Roles and Responsibilities*). For example, consider this quote from a member of the Technical Advisory Committee who felt that appropriate measures were not being taken to protect Research Management Areas:

> "At that last meeting, some of us were shocked how the Research Management Areas fell out based on cost. One of the things that got archived was the Research Management Area to look at disease and I was livid, I was mad and about ready to walk out. If the Technical Advisory Committee suggests putting the disease stuff back in, can it be put back in there?"

These count comparisons do not test quantitative differences between the two cases, but rather they show crude weights for theoretical concepts where stakeholder criticisms are changing over time. Most importantly, these data and criticisms are a product of their different institutional context for each organization, and thus preliminary evidence for different types of criticisms may be apparent. This is supported in the literature; for example, some employees may not have felt comfortable speaking in front of their bosses about organizational problems or issues (Milliken et al., 2003). Because these meetings involved a mix of decision-makers, stakeholders, and their peers, it could be expected that different topics might be approached or discussed. Likewise, for concepts that were not criticized or had very small frequencies of criticisms (e.g., Issue Framing) these concepts do not appear on these charts. The purpose of these charts is to highlight the areas of greatest concern shared by stakeholders from 2015-2021.

8. Discussion

I review the concepts for management, and within each, I also provide interpretations of the findings and discuss their implications. Then I transition to a broader management context based on my findings and suggest how my research could be used to further catalyze triple-loop learning and improve the management of the Florida Reef Tract as a novel marine ecosystem. Finally, I acknowledge the limitations of this study and make suggestions for further research on this topic.

As a reminder, the concepts for novel ecosystem management are areas that managers should consider when making decisions. For example, ignoring Administrative Competence is a possible barrier to management because without considering and implementing the subcomponents of that concept, like selecting the right people for the right job, it can become harder to reach management objectives. Therefore, the relative importance placed on each concept is one way to compare how the institutional foundations of the FKNMS and SEFCRI influence their management styles.

(8.1) Administrative Competence

Administrative competence deals with whether an institution is effectively conserving the ecosystem. For the FKNMS, Administrative Competence focused on direct regulatory actions (like expanding protections to include shallow-water habitats), clear leadership (like directives issued from the Sanctuary Superintendent), and active management concerns (like new regulations to prevent boat groundings on sensitive habitat). In contrast, SEFCRI focused on preventative measures (like identifying areas for future marine zoning) and data collection (like mapping the extent of the northern Florida Reef Tract). So, while the FKNMS and SEFCRI both focused heavily on Administrative Competence, their approaches differed in practice.

These differences reflect the historical and institutional trajectories of these organizations. The FKNMS is an older bureaucratic hierarchy relying on formal institutions. Alternatively, SEFCRI is a newer network that relies more heavily on informal institutions where management actions, such as data collection, are not formally binding but instead inform future policy (Pahl-Wostl, 2015).[18] The following quote from a resource manager, Interview Respondent 7, helps to easily distinguish the core difference between the organizations' power structures:

> "The FKNMS is managed nationally, so there is an inherent entity that is making decisions, whereas SEFCRI exists strictly because there are so many different management entities where the lines [become] blurred."

The FKNMS exists to implement state-mandated regulations legally enforced by clearly defined state actors in leadership roles, such as the Florida Fish and Wildlife Conservation Commission. Direct actions taken on the ecosystem (and the results of those actions) become apparent in viewing examples of how managers tackle conservation goals. For instance, within the FKNMS, twenty-seven wildlife management areas have been designated to protect sensitive wildlife habitats such as bird and turtle-nesting areas. Human access is heavily regulated in these areas, and restrictions are legally enforced (Gershman et al., 2012). These protected areas serve as concrete examples of management actions ongoing in the FKNMS, which reflect the high levels of Administrative Competence seen in my data. To further illustrate this, consider this quote from the Sanctuary Superintendent in 2016, "We have some new science and condition reports to show what's working and where changes may need to be made." This quote was about expanding these Sanctuary Protected Areas, and it demonstrates an iterative and adaptive process aimed at improving results.

Another possible explanation for the differences in how each organization approaches the challenges of Administrative Competence is that the FKNMS has existed for a longer time than SEFCRI (13 years). As such, the FKNMS has had more opportunities to produce results via the management plan objectives drafted in 1997, which have since been updated. Alternatively,

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[18] The FKNMS was formed in 1990 while SEFCRI was formed in 2003.

because SEFCRI is a newer organization with more diverse (and regionally distinct) actors, all of whom worked to develop a plan to address the causes of coral reef degradation, the actors first had to establish clear lines of communication and collect baseline data ("House Natural Resources", 2007). This arrangement in SEFCRI was and still is used to determine appropriate management actions while maintaining and strengthening communication within its network of conservation actors.

(8.1.1) Criticisms of Administrative Competence

In the cases of both the FKNMS and SEFCRI, Administrative Competence received the second-highest level of criticism. These criticisms focused on interventions that had already been implemented that critics said needed to undergo iterative evaluations to maintain their effectiveness as management strategies and apply to the modern setting. This kind of iterative learning and improvement is a critical component of progress for all polycentric adaptive governance systems which seek to maximize their efficiency (Pahl-Wostl, 2015). For example, consider the following quote concerning the use of lobster traps near sensitive reef habitat which needed iterative changes to management to improve enforcement:

> "The suggestion was made to revisit the no lobster trap zones for Acropora.[19] These zones are basically ignored and not enforced. Even though there are zones covering the underwater coral nursery, traps are regularly found inside the zones, and nothing can be done to remove them. Some places that have coral now are not covered [...] These zones need to be reexamined." - Unidentified Representative, Sanctuary Advisory Council

In the case of SEFCRI, because so much of its work has been preparatory (like making recommendations for new types of monitoring), critics called for more direct management actions (like new regulations) and less focus on data collection. SEFCRI's focus on data collection is characterized in their Local Action Strategy, akin to a comprehensive management planning effort made up of discrete building block projects sorted into focus areas (e.g., recreation). The rationale is that if all projects are completed, this will result in a functioning reef

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[19] Acropora is a genus of coral found throughout the world. In the Caribbean, staghorn and elkhorn coral, two *Acropora* species, were once the dominant reef-building corals on the Florida Reef Tract.

ecosystem.[20] Local Action Strategy projects in SEFCRI often include information gathering actions, such as reviewing and evaluating published relationships between reef characteristics or conducting social and economic evaluations of recreational activities. For example, of the 24 completed Local Action Strategy projects under SEFCRI's Fishing, Diving, and Other Uses focus area, 19 included significant elements of data collection and preparation. These elements do not include the types of direct management actions (such as creating and enforcing the zoning regulations seen in the FKNMS today) (Southeast Florida Coral Reef Initiative, 2021).

There have been calls within SEFCRI to shift to a more direct form of management with regulations and enforcement. The following quote addresses a common criticism in this area, the need to ban certain types of fishing gear.

> "At some point, the rubber meets the road. Either gear bans and the like are used, or the system simply degrades–which has been happening for 50 years. When will some ecologically relevant management decisions be applied? If the goals espoused at this and other coral reef meetings are to work, there must be some "wins" for nature, not politics and commerce." - Researcher, Technical Advisory Committee

This quote references the types of fishing gear and practices still permitted on the reefs managed by SEFCRI, which are not allowed in some regions of the FKNMS. For example, vessels in the FKNMS may only enter some protected areas, like the Tortugas Ecological Reserve, if they remain in continuous transit with fishing gear stowed away. Additionally, in other protected areas, like Sanctuary Preservation Areas, fishing or harvesting any marine life is prohibited, meaning all fishing gear is regulated (Florida Keys National Marine Sanctuary, 2011). Without these types of regulations, in some ways the SEFCRI region resembles the wild west, with law enforcement on the water being close to non-existent and the public able to behave with very little oversight.

(8.2) Buffering

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[20] The Local Action Strategy is SEFCRI's version of a comprehensive management plan, like that of the FKNMS. A copy can be found at: https://floridadep.gov/rcp/coral/documents/sefcri-local-action-strategy-2017

Buffering addresses the competency of actors (i.e., state or federal agencies, non-governmental organizations, universities, etc.) to tackle a management problem while facing uncertainty. One of the biggest differences in Buffering observed between SEFCRI and the FKNMS was the ability of the FKNMS to incorporate the results of past projects into future management decisions. In contrast, SEFCRI was often collecting the data for the first time. As mentioned previously, SEFCRI is a newer organization whose directives have been significantly focused on understanding the current status and trends of the northern Florida Reef Tract. This vital research process is still being conducted today. Thus, SEFCRI's projects focus on science (e.g., benthic mapping) to understand ecological processes on the reef tract and build a foundation for future management decisions that might eventually have regulatory authority, rules, and enforcement.

Despite SEFCRI's focus on data collection, one major challenge remained, the need for a no-take protected area, characterized by the following quote:

> "We have been talking about all of these unknowns, but a very powerful management action already exists. We need areas offshore where we don't extract resources. We need areas where you can't remove fish or [substrate] for beach nourishment." - Researcher, Technical Advisory Committee

In this case, while SEFCRI's Technical Advisory Committee acknowledges that no-take marine protected areas are practical and perhaps even necessary, the work being done has not yet incorporated them. The closest thing to a no-take protected area was the creation of the Kristin Jacobs Coral Reef Ecosystem Conservation Area, which was designated in 2018 (putting boundaries around the effective working area of SEFCRI). Plans are in the works for the eventual development of a new management plan with no-take zones (The Nature Conservancy, 2021). Nevertheless, SEFCRI does not operate with the same regulatory authority found within the FKNMS, and the timeline for creating these types of rules remains uncertain.

Key differences between the drivers of degradation were present, resulting in a need for differing management under conditions of uncertainty. For example, the FKNMS often

mentioned tourism as a significant consideration when making management decisions. Tourism accounts for approximately 58% of the local economy in the Florida Keys, so decisions that affect tourism can have broad economic impacts (Office of National Marine Sanctuaries, n.d.). Tourism translates to disturbances on the reefs and runoff from coastal development. SEFCRI's major drivers were the impacts of large population centers, like those found in Miami and Fort Lauderdale, their related effects on water quality, and uncertainty over the best ways to disseminate information about these environmental impacts to the public via outreach. For example, the Technical Advisory Committee discussed how demonstrating linkages between water quality and environmental concerns could help improve management.

SEFCRI's management is the product of voluntary individual behavior across major population centers (e.g., promoting lower uses of fertilizer on homeowner lawns of South Florida to improve water quality in nearshore reefs). For this reason, public engagement to understand the needs of resource users and to inform them on best management practices for reef adjacent communities is essential. The literature also stresses the importance of public engagement and communication in the success of projects that include ecological restoration (Druschke & Hychka, 2015) and even specifically along the Florida Reef Tract (Sturmer, 2020).

There is a difference between the value managers and the general public place on conservation of the Florida Reef Tract (Sturmer, 2020). Through awareness, the public could learn via the help of managers to promote conservation in their daily lives. This problem can be solved through increased transparency and communication (Sturmer, 2020). Druschke & Hychka stress another solution: public engagement and stakeholder involvement must always be a part of an adaptive management cycle. This cycle begins with a problem (e.g., coral reef degradation), prescribes management interventions (e.g., improving water quality), and communicates all successes and failures to the public (e.g., increasing transparency). In this way, stakeholders stay consistently involved.

Research on novel ecosystems and coral reefs in the Anthropocene often highlights buffering, defined as the need to cope with uncertainty while responding adequately to environmental concerns (Good & Bahr, 2021; Hughes et al., 2017a). My research adds to this conversation finding that SEFCRI does this through rich data collection and incorporating more novel considerations into recommendations via their Technical Advisory Committee. Alternatively, the FKNMS does this through suggestions for new zoning, new proposals, and new regulations, which rely more heavily on their statutory power and completed management plans. Despite these differences, coral reefs and the threats they face are dynamic. They require anticipatory management, which carefully considers and incorporates contemporary research into an array of complementary management solutions, such as active coral restoration (a strength of the FKNMS) being coupled with robust data collection (a strength of SEFCRI) (Rogers et al., 2015).

(8.3) Culture and Norms

Culture and Norms explains how SEFCRI and the FKNMS engage with stakeholders, the public, and encourage shared understanding. In their decision-making process, the FKNMS enacted stakeholder inclusion via the Sanctuary Advisory Council meetings. In the FKNMS case, stakeholder involvement was also characterized by involving Monroe County tourism and recreation stakeholders. This was seen as a way to respect the values of local stakeholders who were likely to be impacted by management decisions. Alternatively, SEFCRI focused more on public outreach via engagement with public figures and workshops to raise awareness. SEFCRI focused more on public engagement over an area where the population in 2020 was approximately 6.3 million. In contrast, the population of Monroe county (i.e., the location of the FKNMS) was approximately 83 thousand (U.S. Census Bureau, 2020). Both organizations recognized the need to include stakeholders and the public in participatory processes. Overall, the differences between the two organizations likely depend on their institutional context and the involvement of public outreach and stakeholders in their core objectives and strategies.

An example of engagement with the public can be found in the following statement below, wherein members of the public were trained on identifying coral disease:

> "It all comes down to education and communication [...] For example, I taught someone coral identification, and how to try and characterize [Stony Coral Tissue Loss Disease] [...] they did a survey and found the first sighting of Stony Coral Tissue Loss Disease on a reef outside of Key West—that's a pretty important impact." - Representative, Florida Department of Environmental Protection

This quote shows how far-reaching and effective public outreach can be. Not only did the result of an educational lesson extend outside the SEFCRI region, but it also benefited the entire reef tract. This outreach helped identify the spread of Stony Coral Tissue Loss Disease in sensitive areas like the Dry Tortugas, west of Key West, where until recently, Stony Coral Tissue Loss Disease had not existed (Duong, 2021).

Alternatively, when discussing stakeholder involvement in the FKNMS, Interview Respondent 2 had this to say about involving a local contractor in the decision-making process despite their differences:

> "Do I agree with him all the time? He knows I don't, and I know he doesn't [agree with me], but we're friends, and I can talk to him. So, those are things that I think you accomplish through finding [common ground], you find ways to work with [people], and it takes time, and that's part of the process."

This quote demonstrates the importance of stakeholder involvement for the FKNMS, where competing interests can find common ground through a participatory process and move management decisions forward towards those which protect shared interests.

(8.4) Issue Framing

Issue framing addresses whether an organization properly considers the ecological context before making management decisions. One key management question continually emerged among respondents for issue framing: would combining the two organizations, rather

than keeping them separate, be a better management choice for the Florida Reef Tract system as a whole? Some key differences in management contexts would make this challenging. For example, the two organizations operate within several jurisdictions, engage with the reef tract differently, and prioritize different issues. Therefore, consolidation (while possible) would be problematic. For example, consider this quote from SEFCRI Interview Respondent 9, which illustrates regional differences that might mean that combining institutions would not make sense from a management perspective. They point out the differing ecological stressors, namely coral bleaching from thermal stress, and how SEFCRI's reefs see limited bleaching compared to those of the FKNMS:

> "I will say as a coral reef scientist for this part of the [Florida Reef Tract], we don't see a whole lot of bleaching [...] we're at the northernmost limit. So, I think that's probably why you are hearing from me and everyone else, "water quality, water quality, water quality," we don't get these kinds of changes here, and [climate change] is definitely changing our system, but we don't get these massive bleached areas."

The following quote from the FKNMS Sanctuary Advisory Council meeting minutes also highlights differences between the FKNMS and SEFCRI, where different goals and objectives are implemented in other areas to manage shared resources. The literature suggests that variation in goals can complicate management processes and fragment otherwise cohesive organizational responses, a process which I found evidence for in the case studies for my research (Cumming et al., 2006). Differences in management can affect what topics are of greatest concern locally. Boundaries of fisheries are one policy area that shows where varying goals may fragment policy concerns, where red grouper may be classified as overfished in one region but not in another:

> "In the South Atlantic, red grouper are overfished. It is not likely that the Councils[21] will reach consistency on the grouper regulations [...] The councils reflect regional differences in fishery goals and objectives, and the Keys are right on the boundary."

Another difference in the way managers consider ecological context is that SEFCRI managers focused more on drivers of reef degradation while FKNMS managers focused more on

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[21] "Councils" refers to all of the U.S. National Marine Sanctuary Advisory Councils that contend with red snapper management recommendations.

responses. In the SEFCRI case, several quotes from the Technical Advisory Committee show its managers considering the full context of the northern Florida Reef Tract as an ecosystem that requires adaptive management to persist. In this way, SEFCRI consistently framed the novel ecology of the reef tract and the novel anthropogenic threats to the reef tract in a way that encourages discussion of topics like climate change, coral disease, and new species interactions:

> 1) "The northern Florida reef tract occurs just offshore of the four counties in the SEFCRI region, which accounts for almost a third of Florida's human population. The expansion of the reef tract to this region will for the first time provide better data for managing these resources and controlling threats to the reef."

> 2) "We are characterizing the reefs; characterizing what is happening and where [...] and that is the missing piece that is going to direct us [...] so we can see the changes."

On the other hand, the FKNMS managers tended to steer the conversation away from emphasizing threats to the reef tract (which were already understood in that context) towards framing the correct responses to environmental concerns within a broader ecological context. In other words, SEFCRI looked at the broader ecological context to plan the best management practices. The FKNMS used existing regulations, management plans, and results to iteratively progress *existing* management, which is one possible reason why I saw evidence of iterative learning in this area (Figure 2). Consider the following quote from the FKNMS Superintendent in 2012, "Our long-term monitoring shows management actions are contributing to some positive results, however recovery of ecosystem health takes time." This quote demonstrates how existing management is being adjusted based on previous results.

Additionally, the following quote shows an evolving process of management, where in response to anthropogenic threats, program priorities were being reevaluated to identify new opportunities for new management responses:

> "The Water Quality Protection Program recognizes the continuing water quality issues in [the] FKNMS and has committed to reevaluating the program's priorities and identifying new opportunities to more strategically pursue water quality improvements in the future [...] more detailed action plans will be developed and implemented to further advance the protection and

restoration of [the Florida Keys'] water quality and associated marine resources." - Representative, Sanctuary Advisory Council

This quote demonstrates how FKNMS managers were implementing a new water quality program which is a 20-year collaborative effort to improve water quality around seagrass, coral reefs, fisheries, and recreational access areas. This program was enacted to respond to water quality concerns which have been a threat to coral reefs in the Florida Keys for decades.

(8.5) Power & Authority

Power and Authority deals with whether an institution is well organized, capable, respected, and willing to consider change. Power and Authority received the most criticisms across both organizations in the quantitative data, with criticisms concentrated in interview data (Figure 16, Appendix C). In the FKNMS case, the most important concepts included direct actions to enforce laws and regulations and ensure compliance within marine protected areas (e.g., new fishing quotas or enforcement capabilities). SEFCRI's data often mentioned the leadership roles within their administration and focused on adequate preparation through defining leadership (like clearly stating which actors would be in charge of project implementation) or identifying areas for improvement (like making recommendations on new considerations for water quality monitoring).

(8.5.1) Criticisms of Power and Authority

A lack of centralized authority was commonly criticized in SEFCRI. SEFCRI enacts conservation through dozens of projects spearheaded by various state and non-state actors, which makes regulatory enforcement a challenge, as well as the clarity of roles and responsibilities therein. For example, consider this quote from Interview Respondent 12, describing the importance of The Florida Fish and Wildlife Conservation Commission's (FWC) involvement and how a lack of centralized authority can negatively impact progress. This quote references the substantial length of time required for some tasks within the SEFCRI management regime, in

this case naming the extent of the reef tract. Respondents suggested that the sheer number of

stakeholders involved in SEFCRI management results in it taking longer for decisions to be

made:

> "You know, SEFCRI was formed in 2004 and we finally got a name for that northernmost section of the reef tract in 2019. [...] Does it really take that long? They created 400 national parks in the less time that it took to create a name for 100 miles of reef. And without FWC support, no [stakeholders] are going to buy into anything [...] especially because the [Kristin Jacobs Coral Reef Ecosystem Conservation Area] is in state waters, any sort of decision that is made that would affect fisheries must have FWC support as well—It's so complex, talk about [too many] cooks in the kitchen."

Indeed, research has shown that among larger groups of actors with greater diversity, like

those involved with SEFCRI, policy and decision-making typically generate more conflict,

which may require different considerations to counteract (Lubell et al., 2020). Additional

research has found that in actor networks like SEFCRI, multiple challenges arise from differing

interests, goals, tensions, and other external influences which can hinder management. However,

strategies exist to overcome these challenges, such as building adaptive capacity (i.e., buffering)

through communication, project planning, and shared values (Ayala-Orozco et al., 2018).

Additionally, another interview respondent, Respondent 4, highlighted how a lack of

centralized authority has led to inaction due to the sheer number of actors involved and a lack of

clear direction. In this example, the respondent discussed the use of Local Action Strategy

Projects in SEFCRI to argue that their success depended on individual organizations' desire to

enact particular projects. This dependency resulted in fragmentation where otherwise there could

be an overarching comprehensive plan:

> "The Local Action strategy plans [...] are very much dependent on individuals being inspired to do something with them [...] The individuals concerned with SEFCRI [...] they work for FWC, or NOAA, or the Florida Department of Environmental Protection, or they work for local governments; there are representatives from all the counties [...] So, there's local government, and state government, and some from federal government agencies like the people from NOAA. And so, a lot of this stuff [is] highly dependent on somebody, or some member, being really inspired to pick up one [of the] proposed management activities and run with it."

Politics, namely the whims of elected leaders impacting management, came into play in the case of SEFCRI. For instance, interviews referenced the political mood focusing on former Governor Rick Scott, his policies, and their impacts on the SEFCRI team, including issues of uncertain funding and job security for managers. In 2015, Rick Scott's administration unofficially recommended that the Florida Department of Environmental Protection refrain from using the terms "climate change" or "global warming," a story that received considerable media attention (Korten, 2015). This instance was mentioned many times by interview respondents, who remarked that they suspected that some failures to implement recommendations, such as those generated during stakeholder meetings, resulted from an inhospitable political climate. One respondent noted that after generating plans for public outreach during the Our Florida Reefs initiative, those plans were archived.[22] Another respondent noted, "I knew plenty of people who were absolutely scared [that] they were going to lose their jobs if they were too vocal, and so I think some of the management of SEFCRI were affected by that."

Additional interview respondents mentioned that while funding was a top priority for SEFCRI, it was also a consistent concern. And, while any scientific organization would be potentially affected by these same issues, the difficulties facing SEFCRI were often a combination of internal and external influences. This idea is supported by the literature, which finds that the political mood set by the state plays an important role in effective resource management (Morrison et al., 2020). Political influence can be exerted by people in positions of authority, such as elected officials, to try and alter the outcome of a project based on personal motivations (Banfield & Wilson, 2017). Research on bureaucracy shows that concerns over job security, budgets, and program financing can influence the attitudes and behaviors of managers who are responsible for implementing adaptive governance. This relationship is important in examining institutions' successes and failures and adaptive management that contend with regional ecosystems (Dunning, 2017).

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[22] As a reminder, the Our Florida Reefs initiative is a community planning process, spearheaded by SEFCRI, which aims to increase community awareness and involvement with the reef. For more information, visit: https://ourfloridareefs.org/

For the FKNMS, criticism focused on the implementation of the Sanctuary itself and potential rewrites to the Management Plan. In the FKNMS' early days (circa 1997), the fishing community held the majority of these concerns, namely that the government would overreach and take resources away from people, limiting their abilities to provide for their families or to recreate in areas which they had historically had access. However, much of this sentiment was dispelled via later periods of stakeholder involvement. For instance, during the initial phases of the 1997 Management Plan, proposed zoning was reduced to a fraction of its original extent in an effort to compromise with various fishing stakeholders ("CMC Praises", 1996). A review conducted by the Sanctuary in 2009 found that among the fishing community, opposition to the Sanctuary decreased dramatically from 78.4% in 1996 to 42% in 2009 ("User Group Support", 2009).

Contemporary stakeholder concerns also assert that the FKNMS can be too powerful. In these two quotes from public stakeholders in the newspaper data which mention expanding marine zoning in 2014, concerns focused on a loss of commercial and recreational fishing access:

> 1) "These are areas up to 25 square miles where there will be no recreational or commercial diving or fishing. They'll close it forever. The only thing you can do is drive your boat across."
>
> 2) "The problem is that once we lose [a fishing area], we've lost it forever. We fight [the sanctuary] tooth and nail because when we know we're done, we're done."

While these quotes reflect the type of criticisms that were most common, during my interviews, Respondent 1 suggested that both stakeholder involvement and public outreach had been effective in dispelling these kinds of fears. They also mentioned that learning took place in two directions: from managers to the public and vice versa:

> "There's a lot of policy or community action initiatives that are brought up in those Council meetings. [I get to learn] why the community thinks the way that they do, and then, how we can be representatives of our constituents within the Council [to] move initiatives forward [...] There's certainly pushback from the Community about certain aspects of the plan [...], but as a whole, I

think the community embraces the conservation of [this] critical resource [...], so I think there's a lot of understanding, respect, and appreciation for the sanctuary."

Stakeholders also criticized both organizations for a lack of regulatory enforcement. In SEFCRI, enforcement was not a major component of their approach to management. Alternatively, in the FKNMS, enforcement was often underfunded or lacked personnel. Consider this quote from 2014 in the news data where the Sanctuary Advisory Council emphasized the importance of increasing the presence of law enforcement in the Sanctuary to NOAA:

> "The [Sanctuary Advisory Council] also voted to send a "strong statement" to NOAA leadership, seeking an increase in sanctuary enforcement officers. The resolution notes that enforcement personnel for the sanctuary's 2,900 square miles of water are "at an all-time low, and constituents are demanding more enforcement resources."

Each organization works with the public to encourage voluntary environmental stewardship in response to these concerns. For example, in the FKNMS, in addition to traditional law enforcement, the Sanctuary relies on "interpretive enforcement," which encourages voluntary compliance with regulations through education (Office of National Marine Sanctuaries, 2011). This strategy is also an example of how formal and informal institutions interact. A formal legal situation benefits via social norms, which help encourage compliance and accomplish the ultimate goal of conservation. Further institutional research has found that when differing institutions have similar conservation goals and are operational, these formal and informal institutions can complement each other (Osei-Tutu et al., 2015).

(8.6) Broader Context

My primary objective was to answer two research questions:

1. How does coral reef management vary over the different spatial extents and organizational structures of the FKNMS and SEFCRI?

2. How do these organizations vary in incorporating important aspects of novel ecosystem management?

To answer these questions, I compared the two organizations that manage the Florida Reef Tract and their institutional structures. Given the complexity and scale of the ecosystem, these institutions have developed different methods to respond appropriately to their management needs. However, despite their differences, encouraging cooperative management involves elements of both formal and informal institutions to negotiate the sharing of management functions across the entirety of the Florida Reef Tract (Decker et al., 2012; p. 16). As I have discussed previously, the threats facing the Florida Reef Tract are not the same in Monroe County as they are in Miami-Dade, Broward, Martin, and Palm Beach counties. Thus, it is advantageous to have different institutions that employ various management strategies to approach adaptive governance from different angles (Clement & Standish, 2018). Furthermore, and especially in the presence of common-pool resources, rules appropriate in one region are not appropriate in another, necessitating experimentation to discover what types of rules work best in different contexts (Ostrom, 2008).

Institutional Research has been used as a lens to compare conservation governance responses to ecological concerns in various contexts where common-pool resources are present, a context in which I situate my findings. For example, informal and formal institutions have been compared in water governance (Pahl-Wostl, 2015), fisheries management (Pellowe & Leslie, 2020), livelihoods analysis (Yami et al., 2009), and even forestry (Osei-Tutu et al., 2015). Yet one aspect seems to remain constant across institutional research—that when shared goals are present, informal and formal institutions can complement each other and enable a synergistic effect that compensates for shortcomings in either case. In this way, each institution is tailored to best fit the requirements of the social-ecological system at the appropriate scale. However, they can also benefit from identifying areas for improvement (Cumming et al., 2006).

Additionally, a balance between bottom-up and top-down approaches to environmental governance tends to result in more double and triple-loop learning (Pahl-Wostl, 2009). Therefore, the results I have generated here provide such insight and highlight areas where formal and informal elements can complement one another or shift to fill more functional roles. For example, via the Dry Tortugas Ecological Reserve, the robust regulatory approach of the FKNMS has conserved some of the last semi-pristine coral reef habitats in the Florida Keys. Protected areas like these, along with the enforcement capabilities of the FKNMS, are largely absent in the SEFCRI region, but their necessity was discussed in the Technical Advisory Committee meetings. Alternatively, SEFCRI's collaborative approach consistently engaged researchers from universities like Nova Southeastern University and George Mason University, which may have contributed to their heavier discussion of topics like climate change, coral disease, and new species interactions.

The abundance of learning in my results is encouraging for both organizations. Double-loop learning, a prerequisite for institutional change, was found in SEFCRI and the FKNMS. While single and triple-loop were more common for the FKNMS, the existence of advanced learning in either organization implies flexibility, otherwise known as adaptive capacity (Pahl-Wostl, 2015). For example, the small (single-loop) successes of the Sanctuary Advisory Council, such as ensuring that the best possible team members were always included, has led to much larger (triple-loop) evolutions, such as the creation of additional advisory councils for all of the other U.S. National Marine Sanctuaries. Other examples of single-loop learning for the FKNMS included simple instances of regulatory review or the inclusion of new data, like fisheries surveys, into management recommendations. Alternatively, for triple-loop learning, the Sanctuary's new management plans involved serious reflection on what strategies have or have not worked well. Not only is loop-learning a measure of progress, but its existence implies the presence of adaptive governance (Pahl-Wostl, 2009). Managers from both organizations specifically mentioned a need for evolution in management. For example, in SEFCRI, one manager said that through iterative water quality monitoring, a 'paradigm shift'

was occurring; in the FKNMS, a manager explained that 'innovative strategies' were being consistently used to progress management.

Given that adaptive governance is a necessary component of managing social-ecological systems (and novel ecosystems), its presence helps to show that the strategies of the FKNMS and SEFCRI are being iteratively improved to best fit the needs of the Florida Reef Tract. Indeed, institutional fit, or the process of matching institutional components with ecosystem needs, has been emphasized as critical to progressing management (Ekstrom & Young, 2009). Additional research has also stressed that incorporating learning into social-ecological systems and institutional research is an indispensable tool to improve collaboration amongst stakeholders and decision-makers (Curtin, 2014).

One significant contribution of this research is conceptualizing SEFCRI as an informal institution, an informal system of collaborative management amongst a network of actors. This network includes over 70 participating federal, state, and local agencies, non-profits, universities, and other partners who work together to design and implement the projects outlined in SEFCRI's Local Action Strategy. For example, the Florida Department of Environmental Protection collaborates with both the U.S. Army Corps of Engineers and the Miami-Dade Reef Guard Association, a local non-profit. Research shows that informal institutions can serve a transitional management role in the absence of more formal ones (Haider, 2010). SEFCRI fills this transitional role, managing the northern reaches of the Florida Reef Tract using an informal collaborative management system amongst a network of actors. SEFCRI's transitional role is moving towards more formal outcomes like marine zoning. For example, the establishment of the Kristin Jacobs Coral Reef Ecosystem Conservation Area laid the groundwork for a new management plan and protected areas. While SEFCRI lacks some of the regulatory authority that the FKNMS possesses, it does promote collaborative action between state and non-state actors, such as the Florida Department of Environmental Protection (a state actor) collaborating with universities like the College of Charleston or non-profits like The Nature Conservancy (non-state actors). However, SEFCRI does not seem to have reached a point where the implementation of

their Local Action Strategy projects has generated the kinds of direct interventions seen in the FKNMS. These results are somewhat mitigated by external factors like funding and political support. While some research also shows that informal institutions may compete with others (Pellowe & Leslie, 2020). I did not find evidence that SEFCRI competes with the FKNMS.

In contrast to the informal nature of SEFCRI, the strong, centralized leadership in the FKNMS has enabled decisive actions to conserve and restore the Florida Reef Tract, such as the implementation of more protected areas. The top-down authoritative structure of the FKNMS has also incorporated stakeholders into structured management decisions, a strategy that resource managers in formal governance do not always implement but can use the case of FKNMS to emulate. While SEFCRI also includes stakeholders similarly to the FKNMS—through the Advisory Committee meetings—the FKNMS makes stakeholder engagement a more centralized focus. For example, the FKNMS Advisory Council seats representatives from the diving, tourism, and fishing industries, while the SEFCRI Technical Advisory Committee is composed mainly of research scientists in relevant fields. However, SEFCRI focuses more on public outreach to engage the enormous population centers adjacent to the northern Florida Reef Tract.

Amongst the concepts for managing novel ecosystems (Administrative Competence, Buffering, Culture and Norms, Issue Framing, and Power and Authority), no concepts were ignored by managers. Administrative Competence, arguably the most crucial aspect of management, was frequently mentioned in both organizations' data, reflecting the dedication and know-how to get the job done. Hindrances to management were often external, like funding which directly impacted the ability of managers to implement projects, fund law enforcement, or generate outreach. Topics mentioned within each concept were overwhelmingly positive except in the case of the Power and Authority, where the FKNMS was heavily criticized on aggregate. This criticism mainly originated in stakeholder perceptions that the Sanctuary was overreaching or over-extending their authority, limiting stakeholders' abilities to provide for their families or recreate in areas to which they had historically had access. However, these perceptions have improved over time. Similarly, within the interview data, SEFCRI was heavily criticized for

Power and Authority (Figure 16, Appendix C). In the case of SEFCRI, this was related to people who claimed that roles and responsibilities within SEFCRI were unclear, a likely side effect of it being a large-scale actor-network (Lubell et al., 2020).

(8.7) The Path Ahead

This research has been the first to apply the institutional lens to coral reefs to assess the important concepts for managing a novel ecosystem identified by Clement and Standish (2018). Additionally, this is the first systematic, theory-relevant, comparative case study of the two leading organizations responsible for managing Florida's coral reefs. Before my research, there was limited understanding of how these organizations function and adapt to the new environmental realities under climate change. Therefore, this research supplements the current literature on coral reef management in southeastern Florida and may help inform the management of similarly threatened ecosystems worldwide while setting the stage for further research on institutions and novel ecosystems.

This approach is just one way to explore novel ecosystems, social-ecological systems, and adaptive governance—an information gap identified in the relevant literature (Collier, 2015). Other research suggests that managers, stakeholders, and resource users should collaborate to form formal-informal linkages to avoid unnecessary duplication of resource management and power struggles. This collaboration improves the cohesiveness of large-scale, cooperative ecosystem management, such as the case of the Florida Reef Tract, which deals with common-pool resources (Sokile et al., 2005). Additionally, iterative learning and thus adaptive governance is best achieved when more actors are involved (Pahl-Wostl et al., 2007). The relevant literature echoes this sentiment, emphasizing the necessity of involving a diverse range of actors and modes of governance across organizational boundaries at the regional scale (Clement & Standish, 2018).

Additionally, the role of iterative learning in adaptive governance is paramount and serves as a diagnostic tool to evaluate existing governance routines and enhance both ecological and institutional resilience (Clement et al., 2015; Curtin, 2014). In this way, the FKNMS and SEFCRI present a microcosm of novel ecosystem research where actors are highly diversified across a regional ecosystem, double and triple-loop learning are present, and the local social-ecological context is heavily considered in all decision-making.

Ultimately, the biggest challenges facing SEFCRI seem to be coordination among actors and the departure from a preparatory phase that includes extensive data collection. Interview respondents noted that SEFCRI had excelled in creating a forum where passionate scientists, decision-makers, and other stakeholders were engaging in scientific discussion and generating forward momentum. However, some suggestions from respondents included 1) coordinating with the FKNMS to standardize terminology across the reef tract so that protected area designations, mooring buoys, and posted regulations could be universally recognized; and 2) improving the dissemination of information about the implementation of projects among SEFCRI team members. While these suggestions were not representative of my entire sample, both recommendations encouraged greater transparency and more effective communication. These ideas tie back into the criticisms that there was a lack of clearly defined roles and responsibilities within the SEFCRI's diverse network of actors.

One thing that differentiates the FKNMS from SEFCRI is an abundance of protected areas. However, it was noted in interviews that there might not be not enough enforcement within Sanctuary Protected Areas. Enforcement can be a problem in any natural resource scenario that involves public compliance with regulations. The success of conservation strategies, such as marine sanctuaries, greatly depends on the support and cooperation of the public (Dunning, 2018; Wynveen et al., 2013). Therefore, understanding what drives public opinion and attitudes surrounding environmental issues may be crucial to improving public compliance with environmental regulations and supporting ecosystem management. Future research focusing on how regulatory compliance can be measured and improved in the context of

marine ecosystems could provide further insight. This perspective might also enable resource managers to address questions related to Power and Authority and Perceived Legitimacy (i.e., how the public views management organizations and if they respect their decision-making power).

The role of Power and Authority should not be taken lightly, as it underpins the ability of managers to make decisions, disperse information, maintain public and political support, and achieve objectives (Clement & Standish, 2018). Environmental regulations or restrictions that negatively impact stakeholders' livelihoods, such as no-take zones, catch limits, mooring restrictions, etc., may reduce cooperation (i.e., compliance) with environmental regulations or law enforcement (Maxwell & Maxwell, 2020; Wynveen et al., 2013). In general, regulations are often contentious among stakeholders who may be negatively impacted, such as commercial fishers (Novoa et al., 2016). Regardless of how structured or fair a decision-making process may be, cooperation and compliance among individual stakeholders is key to the success of environmental governance. Enforcement becomes problematic without citizens' cooperation, and conservation efforts are often undermined by harmful, negligent, or criminal activity (Campbell et al., 2012; Maxwell & Maxwell, 2020). Focusing on Power and Authority may help to strengthen institutions. Studies show that trust in government (i.e., perceived legitimacy), resource scarcity, social pressures, and moral inclinations influence individual cooperation and, therefore, underpin the success of environmental conservation initiatives (Dalton et al., 2015; Maxwell & Maxwell, 2020). In this context, the public's perceptions of organizations like the FKNMS and SEFCRI can influence their successes or failures in considering important concepts like Administrative Competence.

Involving stakeholders in participatory governance is always beneficial, even if the inherent tradeoffs generate conflict (Pomeroy & Douvere, 2008). However, involving too many stakeholders can also delay or impede management (Pomeroy & Douvere, 2008). Within my interviews, the reductions to zoning over the years during sanctuary management plan rewrites

were a common concern.[23] However, involving stakeholders always presents the challenge of balancing the wants and needs of stakeholders with what is scientifically, ethically, and legally the right decision (Decker et al., 2012; pp. 39-40). In some cases, like that of marine zoning, concerns over the perceived legitimacy of the Sanctuary were not only limited to people who felt the government was overreaching but to scientists who felt the Sanctuary was failing to protect enough of the resource. However, my data was overwhelmingly positive regardless of these tradeoffs and quarrels.

This research is intended to be used as a stepping stone in novel ecosystem literature, generating new opportunities for advancement and research. As new management plans are developed, the capabilities and institutional arrangements of the FKNMS and SEFCRI will evolve. It remains to be seen what types of institutional arrangements will ultimately have the greatest impact on conserving the Florida Reef Tract, but significant progress is undoubtedly being made.

(8.8) Limitations & Areas for Improvement

There are some inherent difficulties with designing research that accurately encapsulates the management of large-scale, social-ecological systems like the Florida Reef Tract. Future research could benefit from a larger interview sample of stakeholders and managers. Additionally, some of the opinions and perceptions that I was able to elicit likely suffer from internal biases, which are not always apparent and thus difficult to control for. The Florida Reef Tract and the organizations tasked with its management are highly dynamic. Therefore, the data I collected could only be verified using standardized quality assurance and quality control methodologies to the best of my abilities. I also employed triangulation to further increase the validity of my findings across multiple types of data. There are numerous layers of additional data within my dataset, such as dates, agency affiliations, and context. This data could be utilized in future research to answer similar research questions.

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[23] More information about the progress and contents of the current iteration of the Management Plan, the FKNMS Restoration Blueprint, can be found at: https://floridakeys.noaa.gov/blueprint/

While ultimately outside of the scope of this study, future research could look into the results generated by the FKNMS and SEFCRI, which could provide additional insights into how the concepts for novel ecosystem management are being actively incorporated. There are hundreds, if not thousands, of documents that address the direct results, outcomes, and measurable progress of both organizations. However, the demands of the Florida Reef Tract are different at local scales, sometimes making comparative research difficult. Instead, my research has used instances of each concept, across multiple types of data, as a proxy to assess the relative importance of each concept to each organization. Using the institutional and novel ecosystems literature as a theoretical framework is just one of many lenses through which to explore the FKNMS and SEFCRI. Using the differences and approaches to management that I have highlighted here can help build the capacity of managers and decision-makers throughout the Anthropocene.

9. Conclusions

For this research, I used a new combination of several frameworks (including the Novel Ecosystems framework from Clement and Standish (2018) and Pahl-Wostl's Framework for Adaptive Governance (2009) to compare the management of the FKNMS and SEFCRI, the two primary management organizations tasked with conserving the Florida Reef Tract. I examined their underlying institutional structures to analyze their management strategies and explore the interest each organization places on different concepts for managing novel ecosystems. In the process,I was also able to detect the presence of iterative decision-making and management via institutional learning.

My findings showed that double-loop learning was abundant for both SEFCRI and the FKNMS in equal measure. This was a process where guiding management assumptions, such as historical baselines, were being questioned by both organizations–questioning which led to developing new management interventions that reflect changing conditions on the ground. Double-loop learning is a prerequisite to triple-loop learning and shows iterative progress. Additionally, both organizations made Administrative Competence their top priority with variation in their approaches. Administrative Competence for the FKNMS was characterized by regulatory actions, centralized leadership, and active management. Alternatively, for SEFCRI, Administrative Competence was often related to collecting data and planning for future interventions aimed at reducing ecological uncertainty. At its heart, Administrative Competence asks whether managers take conservation seriously. Thus, the importance given to this concept via its prevalence in my data was an essential finding.

SEFCRI focused on incorporating contemporary issues into their management considerations via Issue Framing throughout the data, indicating that novel aspects of the ecosystem were of significant concern. SEFCRI focused on future planning, which incorporated novel ecosystem concepts. This focus is part of a process that the literature refers to as Buffering. It has been identified as a critical aspect of anticipatory management, which generates solutions

that consider the future functions of coral reefs and the services they will provide. SEFCRI generates a wealth of research about the northern reaches of the Florida Reef Tract, which has catalyzed an effort to protect resources that, until recently, were underreported or undiscovered. SEFCRI data emphasize leadership roles among their actors, capitalizing on their decentralized, collaborative approach, deriving legitimacy from multiple actors within their network. That said, the idea that there were too many managers/actors with too many individual projects was also a source of criticism. The voluntary nature of many of its management interventions left SEFCRI to focus more on public outreach–engaging the large population centers around Miami-Dade County. For example, a community planning process, the Our Florida Reefs initiative, designed to facilitate public outreach and stakeholder input, generated priority actions for management. For example, priorities included nominating the SEFCRI region to become a new National Marine Sanctuary or creating a training program for local beach patrol officers to improve recognition of conservation regulations.

Given the formal structure of the FKNMS, there were considerable differences between it and SEFCRI. Due to the top-down, regulatory approach to management that the FKNMS employs, regulations (such as no-take zones) and enforcement are a key part of the FKNMS' management strategy. The FKNMS also used existing regulations, management plans, and results to iteratively progress management, which is why there were more instances of iterative single and triple-loop learning for the FKNMS. For example, past projects and their results were used to inform future management decisions, enabling preparation for future ecological uncertainty. Once again, this reflects the formal nature of the FKNMS and highlights core institutional differences between the structure of FKNMS and SEFCRI. Finally, while the FKNMS emphasized the importance of public outreach to the general public, its priority was the task of *stakeholder* engagement focused on a more narrow group of actors whose livelihoods depend on the reefs of the Florida Keys. SEFCRI, on the other hand, focused on public engagement, with efforts asking individual resource users to adopt behaviors on land such as limiting the use of fertilizers or on the reef such as preventing anchor damage by using mooring buoys to ensure its safety.

Two lines of criticism characterized the FKNMS. First, the FKNMS was criticized for a lack of *perceived legitimacy*, meaning that some stakeholders challenged the authority of the FKNMS to regulate reefs (e.g., commercial fishers) and expressed a lack of trust that their opinions would be considered. Second, scientists and conservationists expressed concern that the FKNMS was not doing enough to conserve the reefs. In contrast, SEFCRI was criticized for a lack of authority, specifically a lack of regulations and enforcement capabilities, as well as unclear roles and responsibilities among the managers in charge. This finding makes stakeholder engagement and public outreach an area of focus for resource managers who wish to improve relationships.

This research has illustrated the global ecological importance of coral reefs and highlighted their immense economic and social benefits, particularly in the U.S. The effects of climate change on Florida's coral reefs have created an opportunity to generate insight into environmental governance via institutional research. This research is the first systematic, theory-relevant, comparative study of the two leading organizations responsible for managing the Florida Reef Tract. Before my contribution, there was limited understanding of how these organizations function and adapt to the new environmental realities under climate change. This research adds to the current literature on coral reef management in southeastern Florida and may help inform the management of similarly threatened ecosystems worldwide while setting the stage for further research on institutions and novel ecosystems.

In summary, using the lens of Novel Ecosystems to conduct my analysis, I found a more formal nature to the FKNMS institutions tasked with management compared to the informal nature of SEFCRI institutions—each model with its own strengths and weaknesses. The FKNMS was one of the first marine protected areas in American waters to engage stakeholders, even those opposed to its existence, while closing stretches of reef tract to extractive activities. Until very recently, SEFCRI often prioritized research and data collection rather than establishing conservation zones on the reef. This focus is likely due to its relative newness compared to the

FKNMS. More importantly, its research and insights are some of the first of their kind to highlight the unique ecological needs of the northerly stretch of reef tract, enabling future management that may come to resemble that of the FKNMS. Last, the way these institutions engage with stakeholders and the public is different. Because of its voluntary and informal nature, SEFCRI engages the wider public through educational campaigns focusing on large-scale actions to protect the reef. The FKNMS targets more specific stakeholder groups and asks them to play a role in management. Understanding the differences in how these institutions function allows us to better understand the way American reefs are managed, possibly generating insights for managers working on reef systems globally.

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11. Appendix

This Appendix includes a copy of my interview questions, as well as additional tables, figures, and information about the supplementary data I collected which reflects the triangulation methodology used to validate my findings.

(11.1) Appendix A: Interview Questions

1. What's your position and/or can you provide a brief description of your role in your agency/organization?

   a. Are you a part of any specific task force(s)?

2. In your opinion, what are the biggest challenges facing the Florida Reef Tract today?

   a. What does the future of the Florida Reef Tract look like to you?

3. Has the role of your department/agency/organization changed in response to environmental stressors climate change?

4. Can you briefly describe the decision-making process in your agency/organization?

   a. Is it difficult to respond to new threats quickly?

   b. When policy changes are enacted, how do you measure success?

5. When you think about the management of the Florida Reef Tract before the advent of coral bleaching, what were management strategies like at the time?

   a. Are there any key differences that stand out to you?

    b.   Is there anything you think could have been done differently?

6. What do you think your agency has done really well in responding to climate change?

7. What roles do public stakeholders have in your organization/agency?

    a.   What are the challenges to implementing stakeholder feedback?

8. Is there anyone else whom you think that I should talk with?

9. Is there anything else you think I should know?

(11.2) Appendix B: Additional Tables and Figures
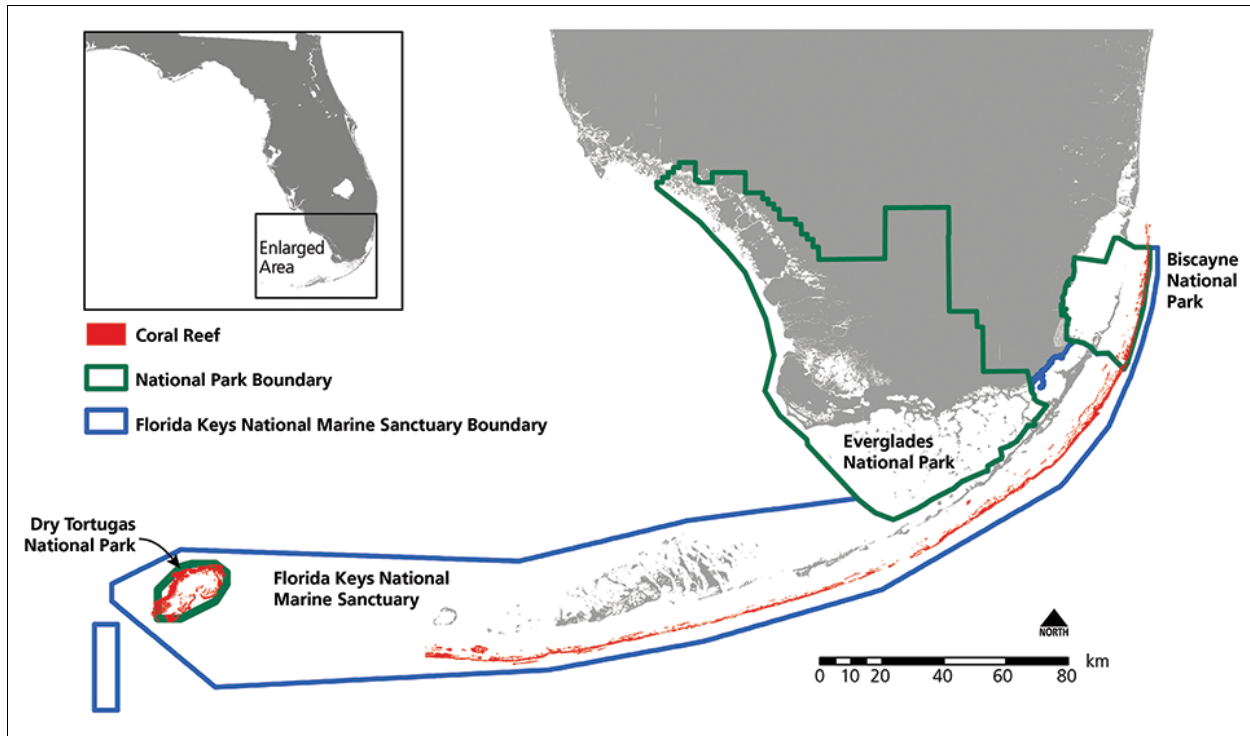
Figure 6. Map of the Florida Keys National Marine Sanctuary (Neely & Ziegler, 2017).

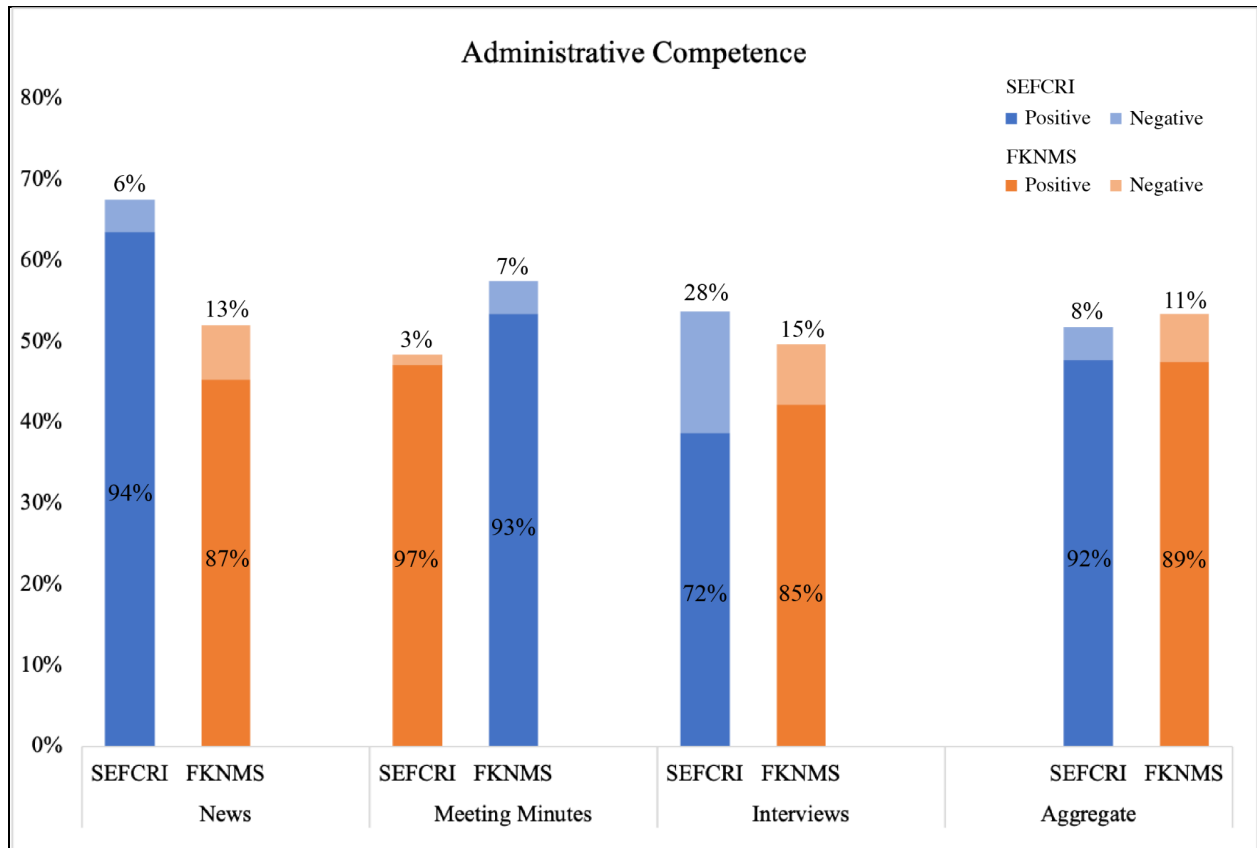**Source: https://www.nps.gov/articles/parkscience33_1_13-16_neely_ziegler_3849.htm**
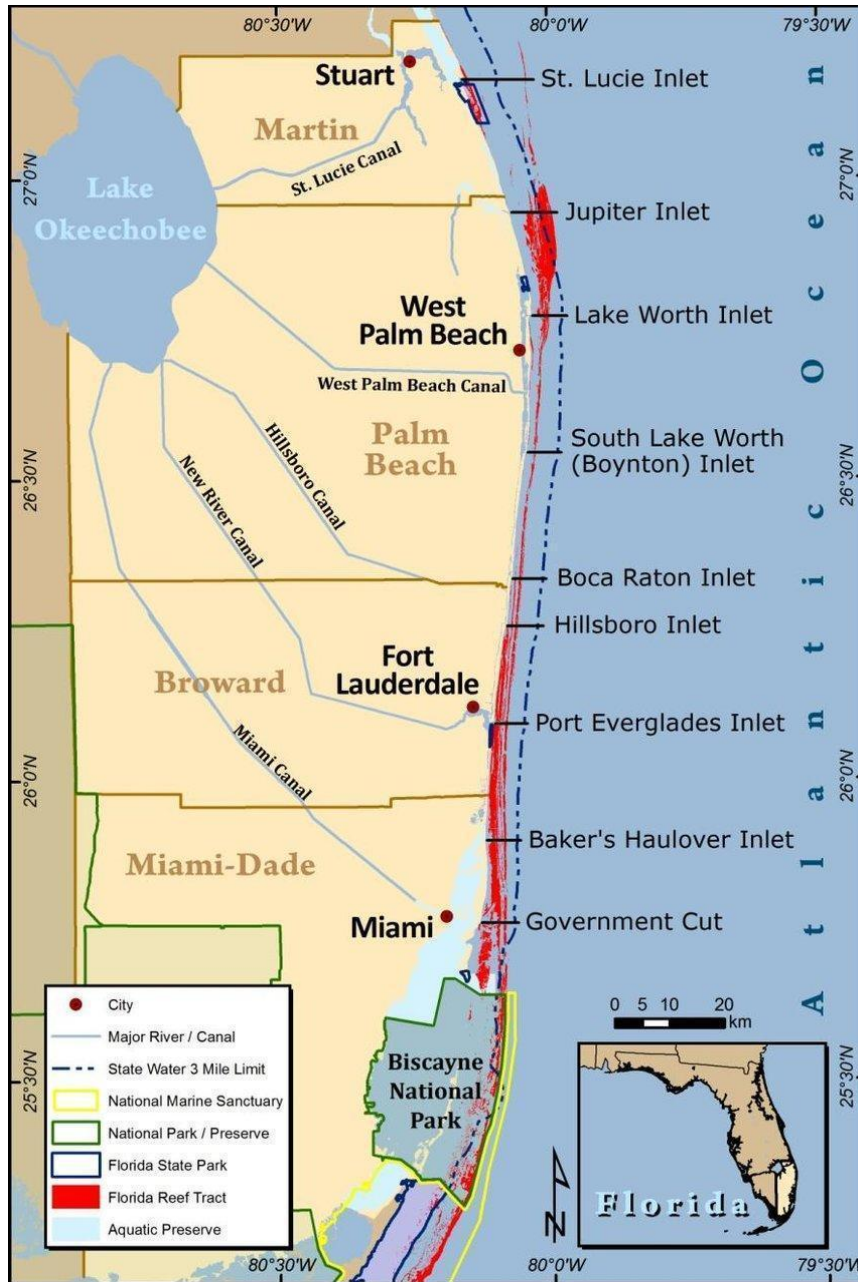
Figure 7. Map of the SEFCRI Kristin Jacobs Coral Reef Ecosystem Conservation Area (Friends of Our Florida Reefs, n.d.)

Source: https://www.floridareef.org/reef-maps.html

(11.3) Appendix C: Supplementary Data

(11.3.1) Administrative Competence

Figure 8. The overall frequency of *Administrative Competence* (i.e., percentage of messages with that code) is displayed on the *y-axis*. The different types of collected data are displayed on the *x-axis* as well as the management institutions. The percentages within each bar indicate the positive mentions (i.e., positive instances) of Administrative Competence. Likewise, the percentages at the top of each bar indicate negative mentions (i.e., criticisms) of Administrative Competence in each relevant dataset. Percentages are rounded to the nearest whole number.

When looking at Administrative Competence in the *news* data (Figure 8), the FKNMS exhibited fewer positive instances of Administrative Competence than SEFCRI and more criticisms. In the news data, Administrative Competence was mentioned for the FKNMS in 0.52 of the dataset; 0.87 were positive, and 0.13 were negative. Meanwhile, Administrative Competence was mentioned for SEFCRI in 0.68 of the dataset; 0.94 of those mentionings were positive, and 0.06 were negative. In this instance, the FKNMS had 0.07 more criticism within

news data than SEFCRI for Administrative Competence. However, the opposite is true in the interview data, where the FKNMS exhibited more positive mentions of Administrative Competence than SEFCRI, but fewer criticisms.

In the *interview* data, Administrative Competence was mentioned for the FKNMS in 0.50 of the dataset; 0.85 of those mentionings were positive, and 0.15 were negative. Meanwhile, Administrative Competence was mentioned for SEFCRI in 0.54 of the dataset; 0.72 of those mentionings were positive, while 0.28 were negative. In this instance, SEFCRI had 0.13 more criticism than the FKNMS for Administrative Competence among interview respondents.

Finally, in the *meeting minutes* data, the FKNMS exhibited more positive instances of Administrative Competence than SEFCRI and more criticisms. Administrative competence was mentioned for the FKNMS 0.58 of the time; 0.93 of those mentionings were positive, while 0.07 were negative. Meanwhile, Administrative Competence was mentioned for SEFCRI in 0.48 of the dataset; 0.97 of those mentionings were positive, and 0.03 were negative. In this instance, the FKNMS received 0.04 more criticism from interview respondents than SEFCRI. A summary of this Administrative Competence data (including *news, meeting minutes, interviews,* and *aggregate* data) can be found below in Table 12.

Table 12. Summary of quantitative findings for *Administrative Competence*. Percentages are rounded to the nearest whole number.

	Administrative Competence							
	News		Meeting Minutes		Interviews		Aggregate	
	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI
Total Statements	225	74	193	401	123	106	541	581
# Statements Using Code	117	50	111	194	61	57	289	301
% Present	**0.52**	**0.68**	**0.58**	**0.48**	**0.50**	**0.54**	**0.53**	**0.52**
# Positive	102	47	103	189	52	41	257	277
% Positive	**0.87**	**0.94**	**0.93**	**0.97**	**0.85**	**0.72**	**0.89**	**0.92**

# Negative	15	3	8	5	9	16	32	24
% Negative	**0.13**	**0.06**	**0.07**	**0.03**	**0.15**	**0.28**	**0.11**	**0.08**

(11.3.2) Buffering
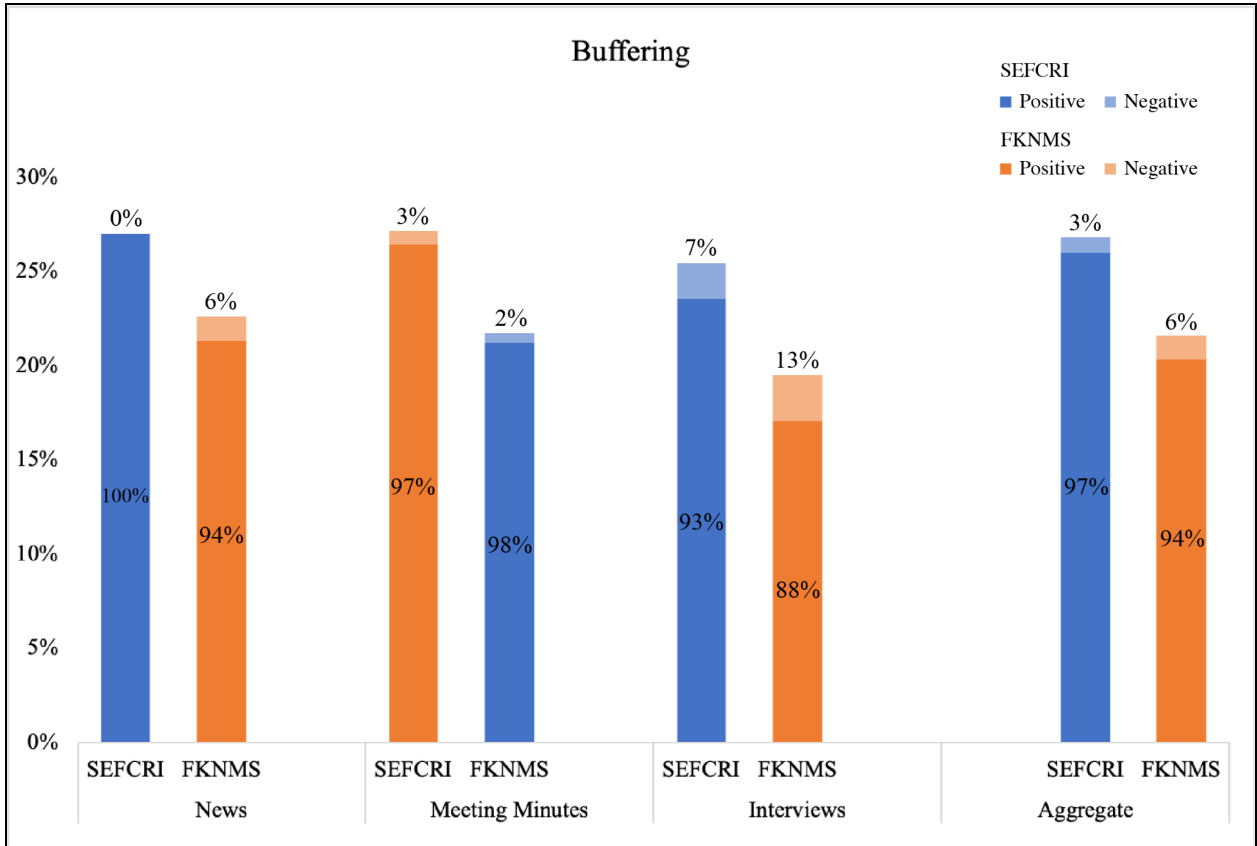
Figure 9. The overall frequency of *Buffering* (i.e., percentage of messages with that code) is displayed on the *y-axis*. The different types of collected data are displayed on the *x-axis* as well as the management institutions. The percentages within each bar indicate the positive mentions (i.e., positive instances) of Buffering. Likewise, the percentages at the top of each bar indicate negative mentions (i.e., criticisms) of Buffering in each relevant dataset. Percentages are rounded to the nearest whole number.

Across the three different datasets, the relationship between the two organizations is similar, where Buffering was mentioned for SEFCRI more often than the FKNMS and criticized less often. However, there was one exception in the meeting minutes data, where SEFCRI and the FKNMS were criticized almost equally (a difference of less than 0.01; Figure 9).

In the *news* data (Figure 9), Buffering was mentioned for the FKNMS in 0.23 of the dataset; 0.94 were positive, and 0.06 were negative. For SEFCRI, Buffering was mentioned in 0.27 of the dataset; there was no criticism. Therefore, 100% of those mentionings were positive.

The *meeting minutes* dataset looked very similar. For SEFCRI, Buffering was also mentioned in 0.27 of the data; 0.97 of those mentionings were positive, while 0.03 were negative. In the case of the FKNMS, Buffering was mentioned in 0.22 of the data; 0.98 of those mentions were positive, and 0.02 were negative.

In the *interview* data for the FKNMS, Buffering was mentioned in 0.20 of the dataset; 0.88 of those minions were positive, and 0.13 were negative. For SEFCRI, Buffering was mentioned in 0.25 of the dataset; 0.93 of those mentions were positive, and 0.07 were negative. A summary of the Buffering data can be found below in Table 13.

Table 13. Summary of quantitative findings for *Buffering*. Percentages are rounded to the nearest whole number.

	Buffering							
	News		Meeting Minutes		Interviews		Aggregate	
	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI
Total Statements	225	74	193	401	123	106	541	581
# Statements Using Code	51	20	42	109	24	27	117	156
% Present	**0.23**	**0.27**	**0.22**	**0.27**	**0.20**	**0.25**	**0.22**	**0.27**
# Positive	48	20	41	106	21	25	110	151
% Positive	**0.94**	**1**	**0.98**	**0.97**	**0.88**	**0.93**	**0.94**	**0.97**
# Negative	3	0	1	3	3	2	7	5
% Negative	**0.06**	**0**	**0.02**	**0.03**	**0.13**	**0.07**	**0.06**	**0.03**

(11.3.3) Culture and Norms
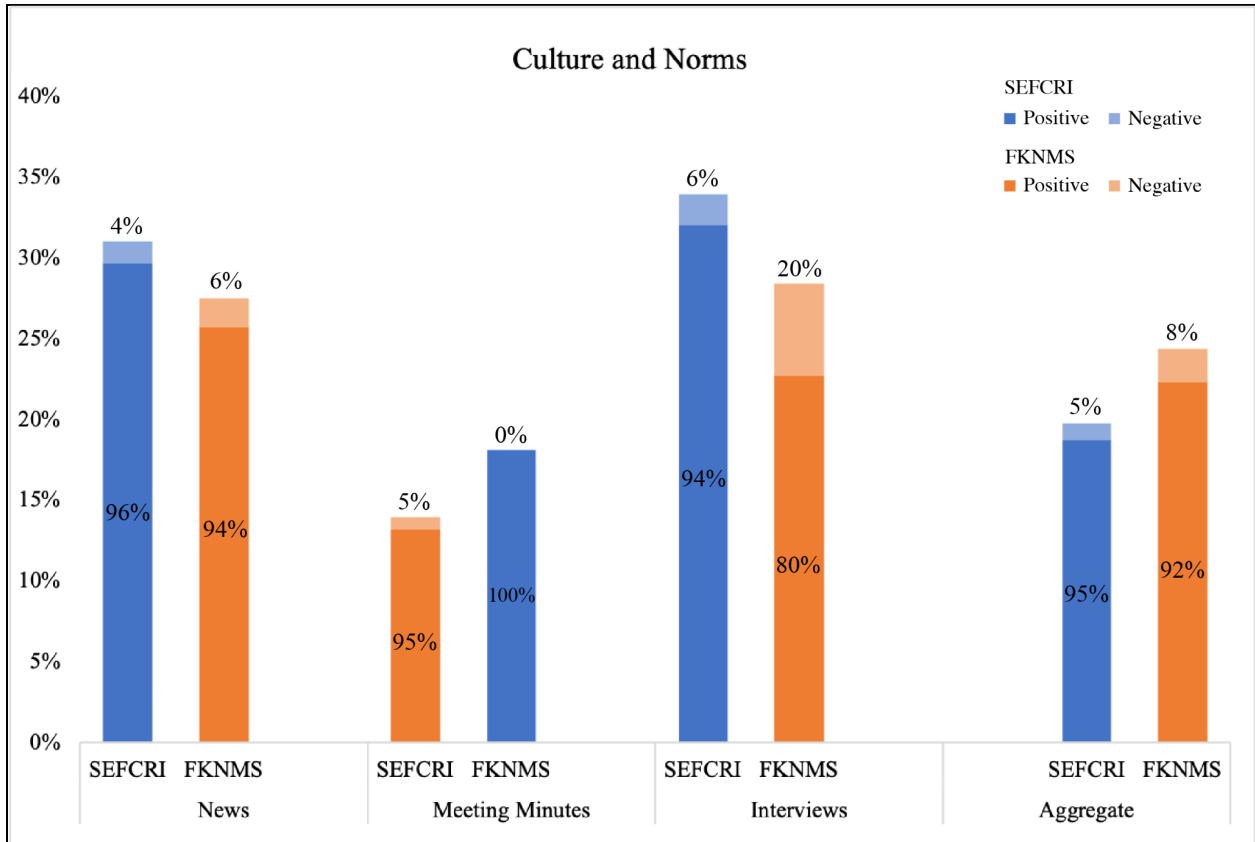
Figure 10. The overall frequency of *Culture and Norms* (i.e., percentage of messages with that code) is displayed on the *y-axis*. The different types of collected data are displayed on the *x-axis* as well as the management institutions. The percentages within each bar indicate the positive mentions (i.e., positive instances) of Culture and Norms. Likewise, the percentages at the top of each bar indicate negative mentions (i.e., criticisms) of Culture and Norms in each relevant dataset. Percentages are rounded to the nearest whole number.

In the *news* data (Figure 10), SEFCRI had more positive mentions of Culture and Norms than the FKNMS and fewer criticisms. Culture and norms was mentioned in 0.31 of the news data for SEFCRI; 0.96 were positive, and 0.04 were negative. For the FKNMS, Culture and Norms was mentioned in 0.28 of the news dataset; 0.94 were positive, and 0.06 were negative.

The graph looks similar between the news data and the *interview* data. However, while SEFCRI still had more positive mentions of Culture and Norms than the FKNMS, it had more than 3x more criticisms. Once again, the interview data included more criticisms for both organizations than the other datasets. For the interview data, Culture and Norms was mentioned in 0.34 of the data for SEFCRI; 0.94 were positive, and 0.06 were negative. For the FKNMS, Culture and Norms was mentioned in 0.28 of the dataset; 0.80 were positive, and 0.20 were negative.

Culture and Norms was mentioned the least for both organizations within the *meeting minutes* data, which qualitatively tended to focus on technical topics, like water quality, and less on public and stakeholder engagement. For the FKNMS, Culture and Norms was mentioned in this dataset 0.18 of the time but had no criticisms, meaning that 100% of those mentions were positive. Alternatively, in SEFCRI's case, Culture and Norms was mentioned 0.14 of the time; 0.95 were positive, and 0.05 were negative. A summary of the Culture and Norms data can also be found below in Table 14.

Table 14. Summary of quantitative findings for *Culture and Norms*. Percentages are rounded to the nearest whole number.

Culture and Norms								
	News		Meeting Minutes		Interviews		Aggregate	
	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI
Total Statements	225	74	193	401	123	106	541	581
# Statements Using Code	62	23	35	56	35	36	132	115
% Present	**0.28**	**0.31**	**0.18**	**0.14**	**0.28**	**0.34**	**0.24**	**0.20**
# Positive	58	22	35	53	28	34	121	109
% Positive	**0.94**	**0.96**	**1**	**0.95**	**0.80**	**0.94**	**0.92**	**0.95**
# Negative	4	1	0	3	7	2	11	6
% Negative	**0.06**	**0.04**	**0**	**0.05**	**0.20**	**0.06**	**0.08**	**0.05**

(11.3.4) Issue Framing
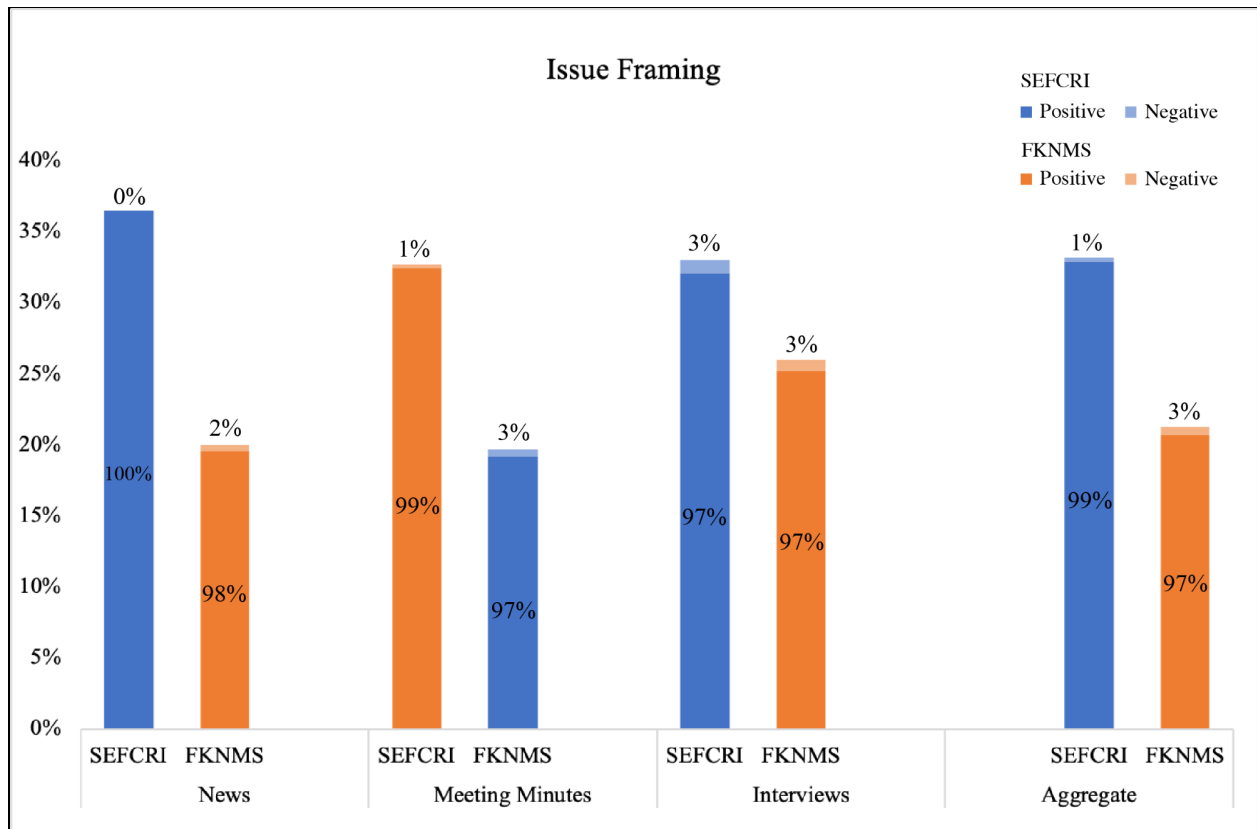
Figure 11. The overall frequency of *Issue Framing* (i.e., percentage of messages with that code) is displayed on the *y-axis.* The different types of collected data are displayed on the *x-axis* as well as the management institutions. The percentages within each bar indicate the positive mentions (i.e., positive instances) of Issue Framing. Likewise, the percentages at the top of each bar indicate negative mentions (i.e., criticisms) of Issue Framing in each relevant dataset. Percentages are rounded to the nearest whole number.

In the *news* data (Figure 11), Issue Framing shows a similar trend to the aggregate data, interview data, and the meeting minutes data. Criticism within Issue Framing was low across the board, and in the news data, SEFCRI showed no criticism at all. Further, Issue Framing was mentioned for the FKNMS in 0.20 of the news dataset; 0.98 of mentions were positive, and 0.02 were negative. Alternatively, Issue Framing was mentioned in the news data for SEFCRI in 0.36 of the dataset; there were no criticisms.

The *meeting minutes* dataset showed very similar results. Issue framing was mentioned for the FKNMS in 0.20 of the dataset; 0.97 of mentions were positive, and 0.03 were negative. Meanwhile, Issue Framing was mentioned for SEFCRI in 0.33 of the dataset; 0.99 of those instances were positive, and 0.01 were negative. Compared to the news data, these numbers are almost identical, with only a 0.01 difference in Issue Framing for SEFCRI and a 0.01 difference for the FKNMS.

Much like the news data and meeting minutes data, the *interview* data displayed a similar trend. Issue framing was mentioned for the FKNMS in 0.26 of the dataset; 0.97 were positive, and 0.03 were negative. At the same time, Issue Framing was mentioned in the meeting minutes data for SEFCRI in 0.33 of the dataset; 0.97 of those mentionings were positive, and about 0.03 were negative. Compared to the news and meeting minutes data, SEFCRI remains relatively stable across positive and negative mentions. However, positive mentions for the FKNMS increased in the interview data. Overall, the stability across the datasets is an encouraging sign for Issue Framing within both organizations. A summary of this Issue Framing data can be found below in Table 15.

Table 15. Summary of quantitative findings for *Issue Framing*. Percentages are rounded to the nearest whole number.

	Issue Framing							
	News		Meeting Minutes		Interviews		Aggregate	
	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI
Total Statements	225	74	193	401	123	106	541	581
# Statements Using Code	45	27	38	131	32	35	115	193
% Present	**0.20**	**0.36**	**0.20**	**0.33**	**0.26**	**0.33**	**0.21**	**0.33**
# Positive	44	27	37	130	31	34	112	191
% Positive	**0.98**	**1**	**0.97**	**0.99**	**0.97**	**0.97**	**0.97**	**0.99**
# Negative	1	0	1	1	1	1	3	2
% Negative	**0.02**	**0**	**0.03**	**0.01**	**0.03**	**0.03**	**0.03**	**0.01**

(11.3.5) Power and Authority
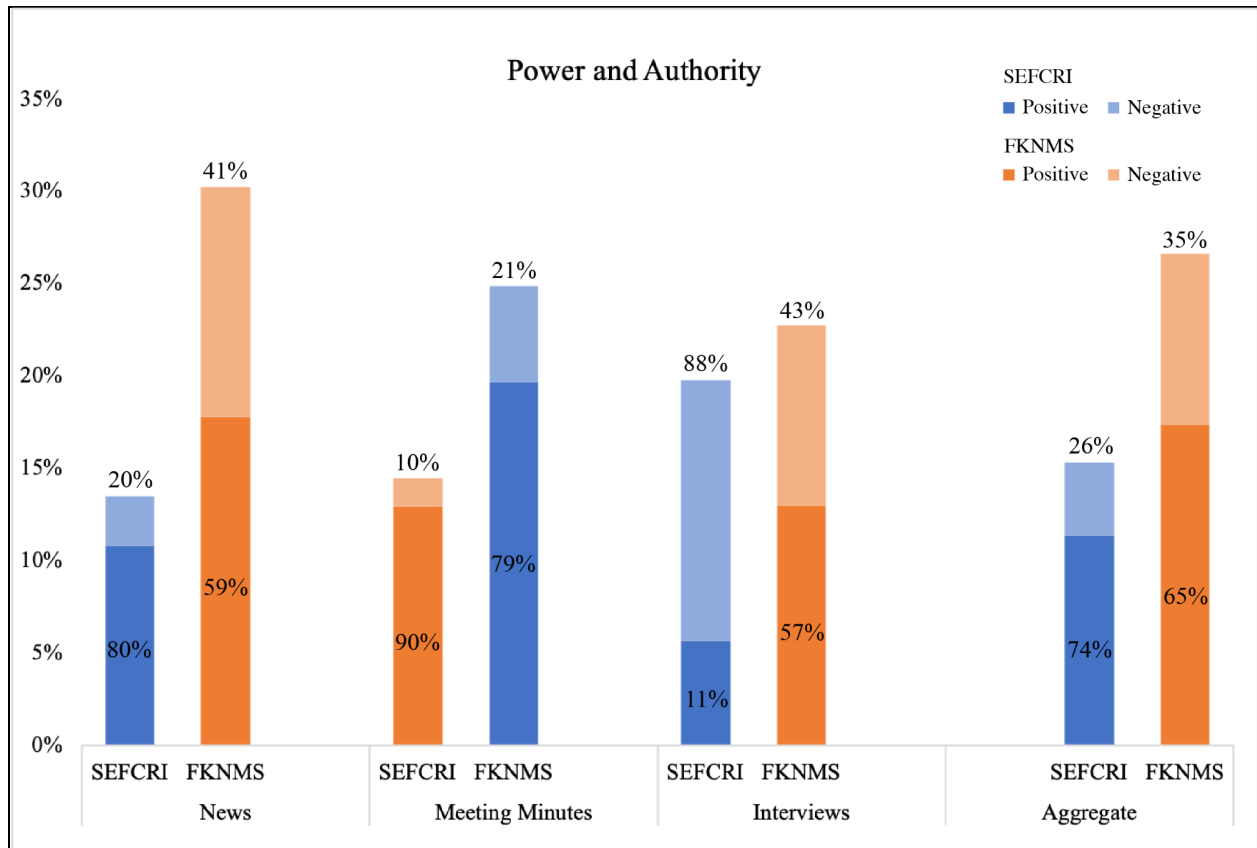
Figure 12. The overall frequency of *Power and Authority* (i.e., percentage of messages with that code) is displayed on the *y-axis.* The different types of collected data are displayed on the *x-axis* as well as the management institutions. The percentages within each bar indicate the positive mentions (i.e., positive instances) of Power and Authority. Likewise, the percentages at the top of each bar indicate negative mentions (i.e., criticisms) of Power and Authority in each relevant dataset. Percentages are rounded to the nearest whole number.

In the *news* data, Power and Authority were mentioned in relation to the FKNMS more than twice as often (Figure 12). The FKNMS exhibited more positive instances of Power and Authority than SEFCRI and more criticism. Power and authority were mentioned for the FKNMS in 0.30 of the dataset; 0.59 of those mentions were positive, and 0.41 were negative. Meanwhile, Power and Authority were mentioned for SEFCRI in 0.14 of the news dataset; 0.80

of those mentionings were positive, and 0.20 were negative. In this instance, the FKNMS displayed 0.21 more criticism within the news data than SEFCRI.

A similar case is true for the *meeting minutes* dataset. The FKNMS exhibited more positive instances of Power and Authority than SEFCRI and more criticism. In the meeting minutes data, Power and Authority were mentioned for the FKNMS in 0.25 of the dataset; 0.79 were positive, and 0.21 were negative. For SEFCRI, Power and Authority were mentioned in 0.14 of the dataset; 0.90 of those mentionings were positive, and 0.10 were negative. The FKNMS displayed 0.11 more criticism within the news data than SEFCRI for Power and Authority.

Lastly, Power and Authority looked very different from the two organizations' *interview* data. Power and Authority was mentioned for the FKNMS in 0.23 of the data set; 0.57 of those mentionings were positive, while 0.43 were negative. Meanwhile, Power and Authority was mentioned for SEFCRI in 0.54 of the interview data; 0.11 of those mentionings were positive, and 0.88 were negative. In this instance, the FKNMS had 0.45 less criticism among interview respondents than SEFCRI. Nowhere else in the data is a concept of adaptive governance so heavily criticized. SEFCRI exhibited fewer positive instances of Power and Authority than the FKNMS and was almost more heavily criticized. Within interviews for SEFCRI, Power and Authority were criticized 2.5x more often than it was commended. This is also the only case where more criticism was present for a concept than positive mentions. A summary of this Power and Authority data can be found below in Table 16.

Table 16. Summary of quantitative findings for *Power and Authority*. Percentages are rounded to the nearest whole number.

	Power and Authority							
	News		Meeting Minutes		Interviews		Aggregate	
	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI	FKNMS	SEFCRI
Total Statements	225	74	193	401	123	106	541	581

# Statements Using Code	68	10	48	58	28	57	144	89
% Present	**0.30**	**0.14**	**0.25**	**0.14**	**0.23**	**0.54**	**0.27**	**0.15**
# Positive	40	8	38	52	16	6	94	66
% Positive	**0.59**	**0.80**	**0.79**	**0.90**	**0.57**	**0.11**	**0.65**	**0.74**
# Negative	28	2	10	6	12	50	50	23
% Negative	**0.41**	**0.20**	**0.21**	**0.10**	**0.43**	**0.88**	**0.35**	**0.26**