

THE MONSTER OF THE VENICE LAGOON: HUMANS, POLICY, OR ECOLOGY?

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Abstratta (Italian)

Questo importante documento di ricerca analizza il grado in cui i quadri di gestione che governano la Laguna di Venezia lavorano per proteggere le varie funzioni dell'ecosistema che si trovano al suo interno e utilizza interviste con le parti interessate come accademici, economisti e sostenitori per capire come si sentono circa l'efficacia di questi quadri e del futuro della laguna. Una revisione delle politiche di importanti documenti governativi, quadri e autorità nella regione ha identificato molteplici lacune sia nella gestione delle risorse che nella comprensione generale dell'ecosistema. Le interviste con le parti interessate hanno dimostrato che le minacce che la laguna deve affrontare non si limitano ai cambiamenti morfologici o ecologici del sistema e alla cattiva gestione; esistono numerose relazioni sociali, politiche ed economiche che sono profondamente intrecciate. Questi componenti sono così controversi che i tentativi di tutela della laguna sono paralizzati dalla necessità di affrontare prima il disordine istituzionale. Si sostiene quindi che fino a quando non si verifica una discussione tra tutte le parti interessate e non si realizza un obiettivo comune per lo stato della Laguna di Venezia, gli sforzi per proteggere e gestire efficacemente il sistema utilizzando quadri attuali sono inutili.

Abstract (English)

This Major Research Paper analyzes the degree to which management frameworks governing the Venice Lagoon work to protect the various ecosystem functions that lie within it, and uses interviews with stakeholders such as academics, economists, and advocates to understand how they feel about the effectiveness of these frameworks and the future of the lagoon. A policy review of prominent governing documents, frameworks, and authorities in the region identified multiple gaps in both resource management and a general understanding of the ecosystem. Interviews with stakeholders demonstrated that the threats the lagoon faces are not limited to morphological or ecological changes to the system and mismanagement; there are numerous social, political and economic, relationships that are deeply intertwined. These components are so contentious that attempts to protect the lagoon are paralyzed by the need to first address the institutional disarray. It is then argued that until discussion amongst all stakeholders occurs, and a common objective for the state of the Venice Lagoon is realized, efforts to protect and effectively manage the system using current frameworks are futile.

Foreword

Attempting to complete a masters degree in the height of a pandemic was not what I had prepared for in my Plan of Study. As the world came to a stand still, I decided to change my research topic to one that I was passionate about and would entertain me through the months I spent locked to my desk.

My family comes from what was once Umago, Italy but is now known as Umag, Istria. As state lines changed throughout history, my family relocated to Trieste, Italy where many still remain today. While my mother always worked hard to uphold our traditions and culture while living in Canada, nothing was more special than being able to travel back to Trieste and be surrounded by a big, loving, and loud family. The path back home was always the same: an indeterminate number of flights and layovers that led us to the tarmac at Marco Polo Airport in Venice, followed by an hour-long train along the coast to Trieste. This is how I was introduced to Venice, and heard stories about her complex lagoon and the threats that beared down on her historic city. I became enamored with learning the history of the Veneto region, how the legendary city was built, and of course, how the complex coastal lagoon could be protected.

As Covid-19 ravaged Italy in the early months of 2020 I wanted to find a way to connect to my family and the place that I loved. That is why for my Major Research Project I chose to analyze the degree to which the ecosystems within the Venice Lagoon, and their functions, is protected by existing water management frameworks. Additionally, I wanted to understand whether these frameworks reflected the expectations, needs, and values of community members and experts and if they feel these governing documents will be successful at protecting and conserving the lagoon.

This paper fulfils the requirements of my plan of study which states that I had hoped to: “assess to what degree water management frameworks governing the Venice Lagoon include ecosystem services as well as the needs and values of community members and stakeholders in the region”. My Plan of Study stated I would achieve this by conducting a policy review and interview various stakeholders within the region. Due to the corona virus, a comprehensive assemblage of stakeholders including general community members posed a challenge. Therefore, this final Major Research Paper does not reflect whether governing frameworks reflect the “expectations, needs, and values of community members”. However, it does focus on the

ecological characteristics of the lagoon, the degree to which governing documents respect the environmental integrity of the lagoon (via a policy review); and finally interviews with select academic experts and professionals in the region were conducted in order to assess if these frameworks meet their conservation or protection expectations.

Each page was a labour of love that I am proud to share with you, I hope you will enjoy.

Acknowledgments

I would first like to thank my family for fostering my passion for the environment and encouraging me to pursue a masters degree in a field that I love. I would like to show appreciation for the numerous teachers in the Masters of Environmental Studies program, each class brought me a step closer to this final project, for the knowledge you gave me I am grateful. My sincerest gratitude goes to my research supervisor Peter Timmerman who helped me keep focus and motivated me to continuously push to ensure this project could reach its full potential.

Support can be shown in many different shapes and forms. This project would not have been completed without the support and love from my friends. Whether it was late night phone calls trying to beat the dreaded “imposter syndrome”, sending encouraging memes, or editing each others papers every part helped to push this project forward. I would be lost without the incredible friendships I have made within my MES Cohort: Andrea B., Badia N., Danielle T., Danielle dS., Steph B., Taylor A., and Taylor S. As well as my life long friends and mentors: Amadeus N., Arlene C., Hannah P. and Sydney S.

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Chapter 1: Introduction

Annually, millions of tourists flock to explore the city of Venice to experience the almost mythical level of beauty that seeps from every turn among the 118 islands that make up the city. The famous and historic city of Venice has been nominated as a UNESCO world heritage site due to the beauty of the city's architecture and historic culture, as well as the canals and gondolas which provide the city with a unique dream-like persona. The city embodies romance, mystery, and wonder — therefore many desperately wish to protect it so that visitors can marvel at its splendor for years to come. However, climate change and human actions threaten to damage, or permanently destroy the islands of Venice, Murano, and Burano, which all reside within the Venice Lagoon. As the historian Peter Ackroyd stated, the story of Venice is fluid in origin, as it is a city with quite literally no roots. These attributes of the lagoon have placed it insecurely in the world and subject to anxiety (Ackroyd, 2009). The academic Ravera stated that the fate of Venice must be considered together with the fate of the Venice Lagoon, as they are all inherently tied together— the anxieties of the city are intertwined with the stresses experienced in the lagoon (2000).

Renaissance humanist Giovan Battista Cipelli, most recognized as Egantius, stated that:

“The city of Venice, founded by divine providence on the waters, is surrounded by water and has water for its walls. Therefore, if anyone in any way should damage these waters, he shall be judged an enemy of the state and shall receive no less punishment than if he had violated the holy walls of the homeland. This ruling is given in perpetuity.” (Caniato, 2005, p. 8).

While human interactions with the lagoon may have changed over time, scholars worldwide demand that we continue to respect the system and maintain the centuries-old vision that Venice and the lagoon be viewed as a single entity. Therefore, it is critical that research dedicated to protecting and conserving the city of Venice considers threats to the health and wellbeing of the lagoon in which it is embedded, should we wish to enjoy the splendor of Venice in its current state and some level of “in perpetuity”.

This Major Research Paper aims to provide an overview of the Venice Lagoon, analyze the degree to which management frameworks of the Venice Lagoon work to protect the various ecosystem functions that lie within it, and what various stakeholders such as academics,

economists, and advocates feel about the effectiveness of these frameworks and the future of the lagoon. This project can be broken down into three parts: an ecological assessment of the Venice lagoon; an analysis of the documents that govern the lagoon; and interviews with various experts and community members. The ecological assessment of the Venice Lagoon will paint a picture of the Venice Lagoon system, from species and geographical features to ecological functions and threats to the system's survival. Understanding the biological processes, and truly knowing the lagoon's various ecosystem functions will be crucial to the policy review portion of this study that will follow. The analysis of documents that govern the lagoon will aim to understand whether existing frameworks, policies, or legislation are able to effectively protect the system in order to identify opportunities for improvement, or praise. Finally, interviews with experts and stakeholders will provide greater context to the challenges the lagoon system faces and whether they feel existing or proposed legislature can address them.

The policy review was effective in this respect as it identified gaps in legislation in regards to ecosystem management; however, if sustainable environmental management is not the priority of citizens, decision makers, stakeholders, advocates then do these types of analysis matter? As interviews with stakeholders occurred, it was revealed that although numerous policy reviews can be made and legislative analyses can be conducted, until a broader discussion amongst all stakeholders regarding the future of the lagoon occurs, efforts to effectively manage the system are essentially futile.

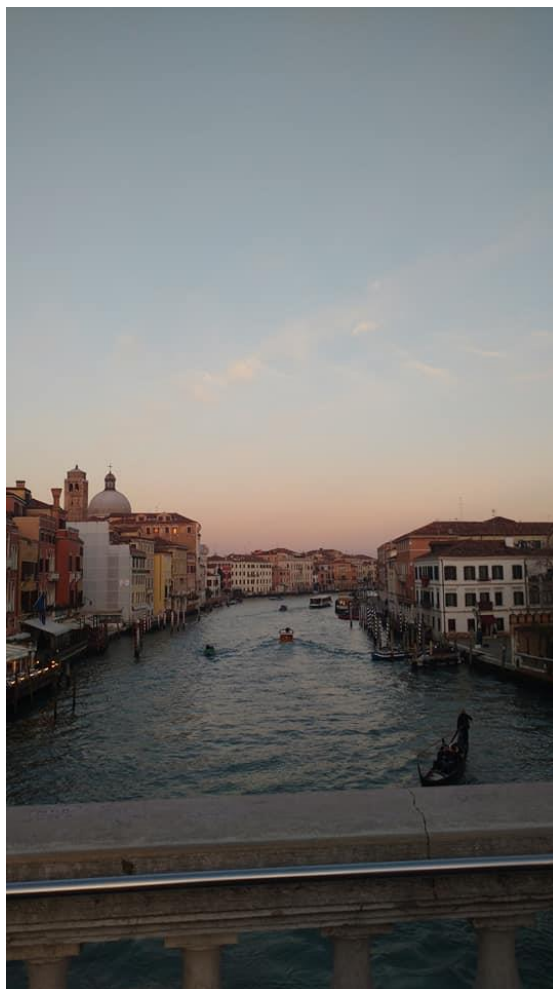
Chapter 2: The Venice Lagoon: Painting a Picture

Before diving into an analysis of the protection of the lagoon, a portrait of the lagoon must be painted. The geographic and ecologic characteristics of the lagoon must be understood in order to truly appreciate and understand the complexity of the system. Only then can a policy analysis accurately encompass whether the ecological needs of the lagoon are being met in the frameworks and documents that serve to protect them. This section will first transport you to the coastal lagoon in a marginal sea in the Mediterranean. The geographic attributes that define the lagoon will be detailed, followed by a description of the ecological features of the lagoon. The ecological, historic, and cultural significance of the lagoon will be explored in a section dedicated to the uses and functions of the system. This all serves to provide greater context to what is at stake — there are countless environmental and human impacts that threaten to damage or even destroy the lagoon. Climate change, cruise ships, even the structure of the lagoon are a danger to its longevity, and all will be depicted to illustrate the conditions the lagoon faces and what it needs to be protected from.

2.1 History and Uses of the Lagoon

Founded in the 5th Century, Venice would become a major medieval maritime power in the Mediterranean, and it grew throughout the centuries to become the beautiful, romantic, and mysterious ancient city that is visited by millions today (Molinarioli, Guerzoni, Suman, 2019). The famous city reached the height of its political and commercial influence during the fifteenth and sixteenth centuries due to its optimal location, which allowed the city to act as a point of control for maritime routes (Caniato, 2005). This power allowed Venice to establish its legacy as an emporium of trade and connecting port between the Middle East, the Mediterranean coasts and continental Europe from its founding until the present day — where it still remains an active port (Caniato, 2005). Since the fall of the Venetian Republic in the eighteenth century, the beauty of the city and its labyrinthine canals have held its grip on the world's imagination and inspired poets and artists to marvel at the ornately marbled and frescoed churches and domes that scatter the landscape and reflect the brilliant blue waters of the lagoon. Those who visit the city, whether in the flesh or transported by film, photograph, painting, or prose, are borne in a time capsule of some of the most prominent artistic and architectural genres that can be explored at every curve

and lane across the island — notably the Venetian Gothic architectural style that strongly characterizes the city landscape, and numerous other buildings that grace the Grand Canal.



Personal image of the Grand Canal

While many consider Venice as ‘the city on the sea’, in actuality Venice is an island that finds protection by lying within a lagoon that has centuries-old sand bar barriers that serve as its fortress walls. It is this fortress-like lagoon that will be discussed extensively within the following pages of this paper. However, first a description of the uses of the region must be provided.

Until a few decades ago, Venice was the heart of a residential environment that was densely populated— nowadays, however, the lagoon hosts numerous abandoned settlements that had been used for centuries by fisherman, sailors, boatmen; and others that relied on local agriculture and trade (Caniato, 2005). Regarding the population of the city and lagoon basin: in 2005 it was

recorded that over one million people currently inhabited the Venice Lagoon basin (Suman, Guerzoni, & Molinaroli, 2005). The population of the historic city itself has witnessed various fluctuations in population, but notably there was an extreme decrease in inhabitants on the main island from 175,000 persons in 1951 to less than 70,000 in 2005 (Suman, Guerzoni, & Molinaroli, 2005). It is believed that this exodus might have been instigated by lack of employment, high real estate values, high costs of building maintenance, and flooding events (Suman, Guerzoni, & Molinaroli, 2005). Today, population statistics approximate that there are fewer than 55,000 people actually living in the city, and roughly 270,900 people residing in the larger commune of Venice (BBC, 2016). On average, Venice loses around one thousand residents each year, which some advocates fighting against the depopulation of the city say will eventually liken Venice to Pompeii as a destination for tourists to stop and visit to marvel at, but not as a residential area (BBC, 2016).

The rapid decline of the Venetian residential population is attributed to lack of employment, among other factors which were previously mentioned; obviously however tourism is a key source of financial input for the region and those that live within it. Today, tourism can be considered as the economic driver of the historic city, as it employs over 10,000 people and generates over a billion euros in annual revenues. The city is considered as one of the most important tourist attractions in Italy attracting over ten million visitor days annually (Suman, Guerzoni, & Molinaroli, 2005). Of course, this industry, although lucrative, applies additional stress to the lagoon, the city, and its inhabitants — which will be discussed further in the portion of this paper dedicated to exploring the threats to the lagoon.

The Port of Venice is known as one of the principal ports in the northern Adriatic Sea. A report in 2005 assessed that annually, the port handles 30 million tons of cargo and employs over 18,500 people (Suman, Guerzoni, & Molinaroli, 2005). Additionally, over five thousand vessels visit the Port of Venice annually, while a further five hundred vessels dock at the Port of Chioggia (Suman, Guerzoni, & Molinaroli, 2005). Port traffic is comprised of ships transporting bulk industrial goods, containerised cargo, petroleum and hydrocarbons. Of course, passengers (due to local and tourist-based transit) also contribute to traffic within the lagoon. It is estimated that over one million maritime passengers transit Venice each year (Suman, Guerzoni, & Molinaroli, 2005). It is estimated that the commercial interests from the Ports garner over 1250

million euros in economic activity each year, therefore strongly influencing the resource management frameworks within the area (Suman, Guerzoni, & Molinaroli, 2005). What is often overlooked when discussing the Veneto region and the ancient city is that Venice is today an important industrial centre in Italy and the northern Adriatic region, as well as a significant port. The various industries that claim space along the mainland shore include: petrochemical processing, shipbuilding and maintenance, coal distillation, fertilizer and pesticide production, and non-ferrous metallurgical processing (Suman, Guerzoni, & Molinaroli, 2005). The majority of the enterprises are located in the Porto Marghera region of the mainland approximately 5 km west of the city centre (Suman, Guerzoni, & Molinaroli, 2005).

There are various food provisioning industries that rely on the well-being of the lagoon in order to sustain local residents and provide additional economic inputs to the region. These will now briefly be discussed. In one of the southern most parts of the lagoon (Chioggia), lies the principal fishing port of the Venice Lagoon, which employs over 1200 fisherman (Suman, Guerzoni, & Molinaroli, 2005). Clam and mussel cultivation are important activities within the lagoon. Aside from commercial or recreational fishing, there are over 120 fish farms along the western border of the lagoon that range in size from 10 to 1600 hectares (Suman, Guerzoni, & Molinaroli, 2005). Income from aquaculture is estimated to amount to six million euros annually (Suman, Guerzoni, & Molinaroli, 2005). However, the formation of these facilities required the damming of canals that formerly permeated the lagoon wetlands, once again demonstrating the constant trade-offs that can be identified with industry and ecological relations within the region. In addition to aquaculture, or fish farming, agriculture is an important industry within the drainage basin of the Venice Lagoon as over 80,000 farms reside over 3130 km² of land (Suman, Guerzoni, & Molinaroli, 2005). Important crops or products from this industry include corn, cereals, and of course livestock production (namely cattle and pigs) (Suman, Guerzoni, & Molinaroli, 2005).

Next a geographic and ecological description of the lagoon will be provided in order to better paint a picture of how the lagoon ecosystem operates where some of these demands are located.

2.2 Geographic and Ecological Features of the Lagoon

Arguably, the Venice Lagoon is one of the most well-known geographic features of Italy, as it is home to the fish shaped city that remains in its midst standing despite all odds. When you

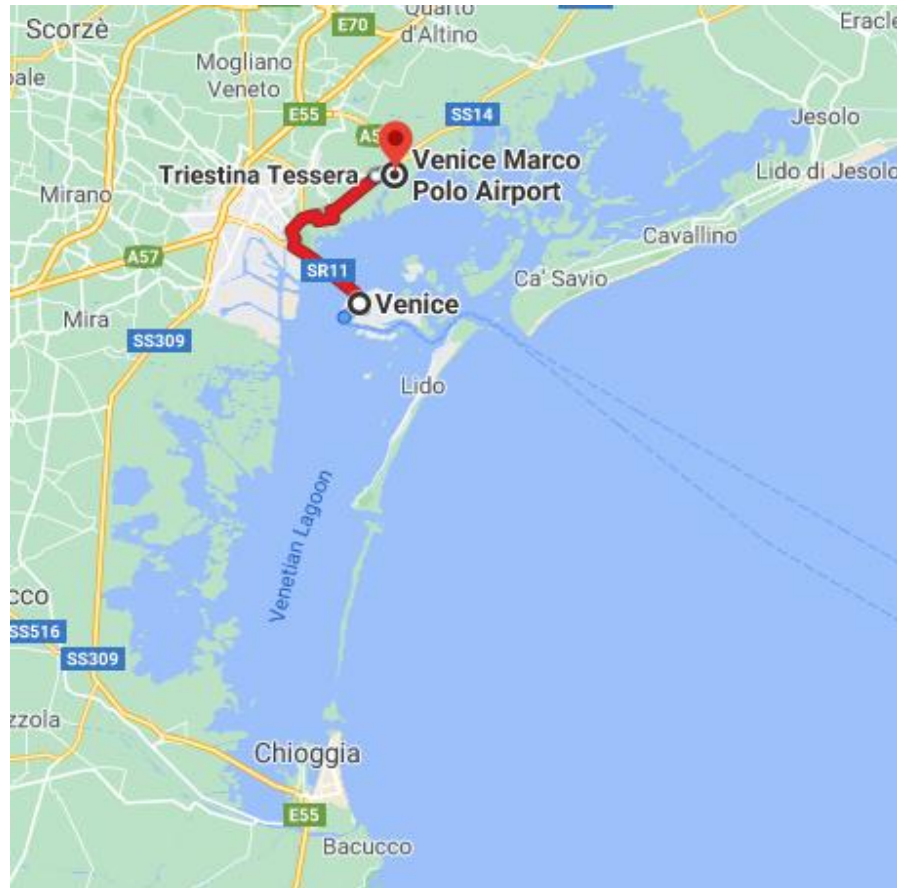
arrive at Marco Polo Airport you rest on the banks of the north end of the lagoon. Depending on your flight path, you may have been able to steal a glimpse at the bluey green waters that embrace the city. Upon arrival, a 15-minute bus ride from the airport to Mestre Stazione takes you one step closer to the wonders of St. Mark's Basilica, Ponte di Rialto, and the numerous renowned art galleries and other attractions dispersed about each island. To unlock the wonders of Venice, you must cross the lagoon. Whether by water taxi, train, automobile, or walking the Ponte della Libertà—the crossing of the Venice Lagoon is almost ritualistic. Watching the waves crash in anticipation as the city slowly reveals itself to you is as much a part of experiencing Venice as riding a gondola or sipping Aperole spritz by a bridge.



Personal image of Piazza San Marco and the lagoon from the San Giorgio Maggiore bell tower

Sometimes, the lagoon is dismissed by travelers or considered as an obstacle that must be crossed via destructive motorboats in order to access the ancient city or transport goods from shore to sea (Caniato, 2005). Conversely, the lagoon is also sometimes acknowledged as the necessary backdrop that provides ambience for its legendary islands and is an ecosystem that needs to be conserved due to its uniqueness and beauty (Caniato, 2005). Scholars hope that we can expand our appreciation for the lagoon and demand that the larger ecosystem be conserved not just for the aesthetic appeal it brings, but conserved because it should be considered as a living organism, sustaining valuable ecosystem functions that permit Venice to exist as a cultural

capital within Europe. Below is a map of the entire Venice Lagoon, from the inlets that exchange water between the lagoon and the Adriatic Sea, center of the city Venice, the lagoon's location relevant to the map of Italy, and of course your route of travel from Marco Polo Airport to the city center.



2.2.1 Venice Lagoon Morphology

The Venice Lagoon is located at the northwestern end of the Adriatic Sea, which is a marginal sea in the Mediterranean. The Venice Lagoon is 55km long, 15km wide, has a surface area of 550km² and has a watershed of 1800km² (Ravera, 2000). Since the time of the Venice Republic, many human interventions, such as diverting main water courses that feed into the lagoon, have been constructed (Ravera, 2000). While early inhabitants of the lagoon altered the structure of the system by diverting freshwater inputs, 20th century modifications have included creating jetties at the inlets of the lagoon and dredging the Malamocco-Machera channel (Rova, Pranovi, Müller, 2015). Recently, a hot topic surrounding the lagoon is the MOSE project which refers to hydrological barriers that plan to close off the inlets to protect the historic city of Venice

from flooding. Human interference combined with natural and anthropogenic subsidence, is accused of causing the significant changes that have affected the Venice Lagoon (Rova, Pranovi, Müller, 2015). At the same time, the morphological evolution of the lagoon at the hands of human intervention, motivated by maintaining the ever-fragile equilibrium between land and water, has been credited by many as the reason why the city has been able to survive for so long. It was observed that through these human interventions, by 1968 more than 50% of the natural lagoon had been reclaimed for business-related purposes, (e.g., industrial complex of Porto Marghera, fishfarming) (Molinaroli, Guerzoni, & Suman, 2019). All these changes have contributed to the amplified flood surges the region has been experiencing, therefore demonstrating that some, if not all, of the human modifications have been to the detriment of the lagoon (Molinaroli, Guerzoni, & Suman, 2019).

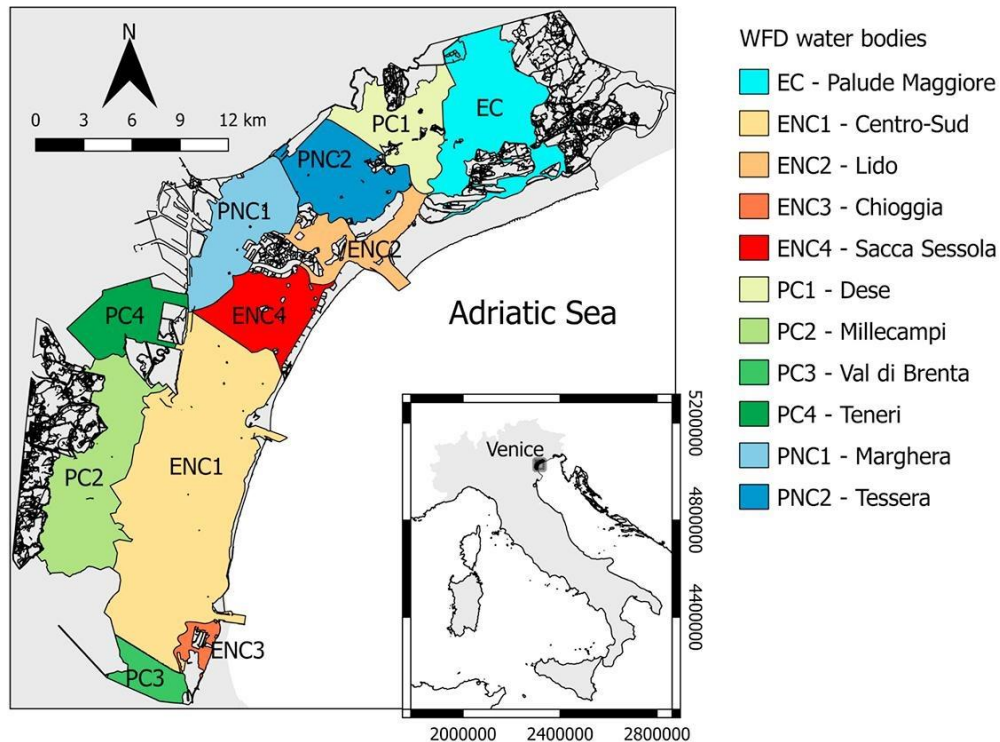
The modern-day lagoon began to form around 6000 years ago when rising sea levels flooded the easternmost point of the Po Plain. This flooding event created a coastline characterized by multiple small cusate (where various accretions meet and shape) deltas and estuaries of the Po, Adige, Brenta, and Piave rivers (Spencer, Da Mosto, & Fletcher, 2005). The lagoon is protected from the Adriatic Sea by sediment barriers — sandbars — that are broken up by three inlets: Lido, Malamocco, and Chioggia. It is through these openings, or *porti*, that the sea can rush into the lagoon; and as the historian Peter Ackroyd eloquently stated, it is these tides that, “breathe life into Venice” (Ackroyd, 2009, p.16). Should the *porti* be considered the breath of life that enters the system, then the network of major channels and minor canals that connect the Venetian sea ports to the river deltas of the mainland can be considered as the veins and arteries of a living organism (Caniato, 2005).

Since the lagoon acts as a buffer zone between the Italian shoreline and the Adriatic Sea, the ecosystem is considered to be an ecotone as it is a transition area between two different biological communities that allows the two different communities to meet and integrate (Ravera, 2000). The Venice Lagoon is a complex system, as with many ecotones, due to the fact that many variables must be considered in order to truly understand how the system functions. The system is considered open because it exchanges material and energy with both the sea and its watershed (Ravera, 2000). Additionally, the system is considered to be dynamic because the physical, chemical, and biological characteristics of the lagoon vary continuously over time (Ravera, 2000). The Venice Lagoon, like most lagoons, is liable to major and sudden variations

which consequentially results in an unstable equilibrium (Ravera, 2000). This instability is what causes great changes in the structure of lagoons which causes them to eventually evolve into either marine bays or follow through the natural succession of becoming a saltmarsh, and then eventually resulting in dry land (Ravera, 2000). Essentially, the Venice Lagoon is a beautiful system, but can be considered highly unstable due to its complex, open, and dynamic nature. This makes understanding its health and wellbeing an intriguing challenge for researchers.

2.2.2 Water Bodies in the Venice Lagoon

On average, the daily freshwater input to the Venice Lagoon is around 2.8 million cubic meters (Suman, Guerzoni & Molinaroli, 2005). Between the mainland and the Adriatic lies the lagoon, this hydrological pattern of freshwater and salt water inputs creates a typical brackish environment in the lagoon, with a salinity gradient that ranges from 10 ‰ near the mainland border to 32‰ at the inlets (Suman, Guerzoni & Molinaroli, 2005). The management plan “Hydrographic district of Oriental Alps, in accordance to the Water Framework Directive”, divided the Venice Lagoon into eleven different bodies of water, based on a combination of hydrological descriptors, existing pressures, chemical and ecological states (Rova, Müller, Meire, & Pranovi, 2019). The categories are listed as “polyhaline confined” (PC), “polyhaline not-confined” (PCN), “euryhaline confined” (EC) and “euryhaline not-confined” (ENC) based on their salinity and degree of confinement (Rova, Müller, Meire, & Pranovi, 2019). *Polyhaline* and *euryhaline* indicate salinity levels within the range 20–30 and 30–40 psu (Practical Salinity Unit), respectively (Rova, Müller, Meire, & Pranovi, 2019). *Confined* refers to the inner parts of the lagoon, determined by salt marshes areas where water exchange is low (Rova, Müller, Meire, & Pranovi, 2019).



(Rova, Müller, Meire, & Pranovi, 2019).

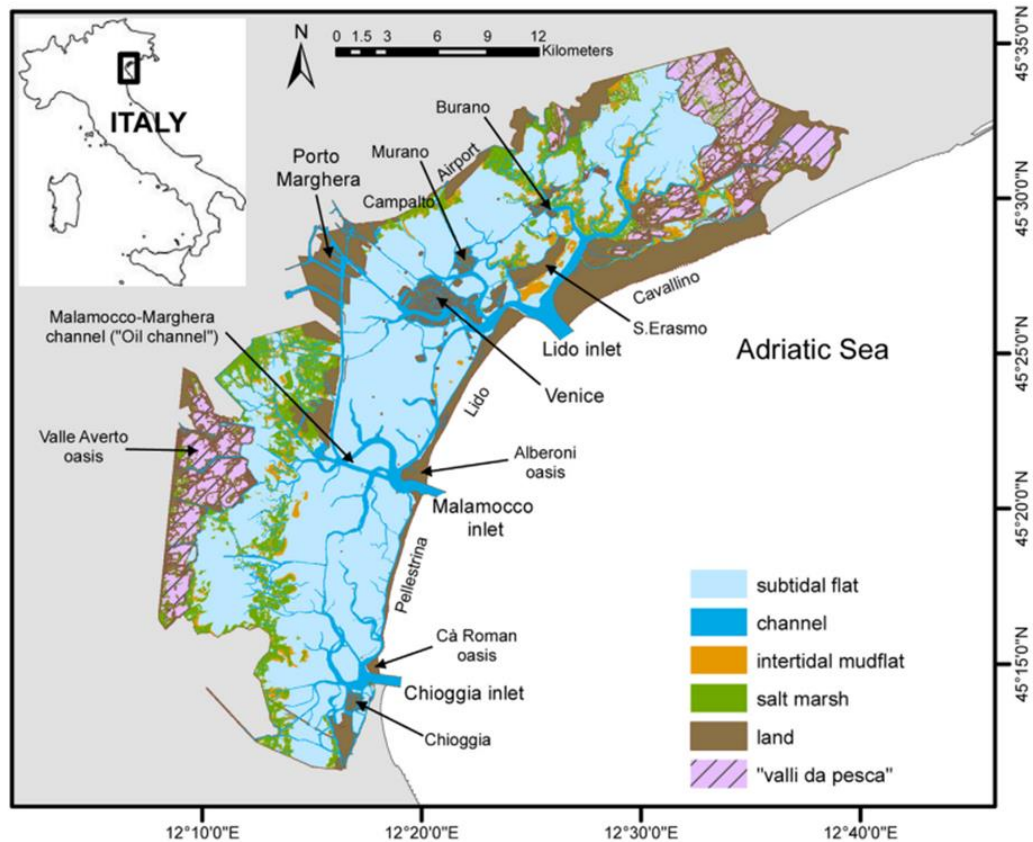
Originally, four major rivers (Sile, Piave, Brenta, and Bacchiglione) drained into the Venice Lagoon, transporting a bountiful supply of fresh water, sediment, and organic matter. Before 1500, the rivers that entered the lagoon supplied approximately 700,000 m³ of fine-grained material, most of which accumulate to form the fringing salt marshes and mud flats (Suman, Guerzoni, & Molinaroli, 2005). Additionally, roughly 300,000 m³ of sand entered the lagoon from the sea to form flood tidal deltas (Suman, Guerzoni, & Molinaroli, 2005). By 1650, all major rivers had been diverted in order to circumvent the lagoon and discharge the water and its contents directly into the sea in order to avoid lagoon siltation (water pollution that results from silt or clay particle accumulation) (Suman, Guerzoni, & Molinaroli, 2005). Today, the lagoon's sediment budget is negative which indicates that more sediments are being removed from the lagoon than are being deposited (Suman, Guerzoni, & Molinaroli, 2005). These diversions, combined with the creation of breakwaters (breaking the force of the sea) and jetties (structures that aim to influence currents or tides) at lagoon inlets, as well as the increased dredging of lagoonal channels for navigational purposes, have significantly influenced the lagoon's morphology — leaving it to look very different today from how it originated. (Suman, Guerzoni, & Molinaroli, 2005). There are twelve major tributaries that feed surface runoff of

freshwater, heavy metals, and nutrients from the large drainage basin into the Venice Lagoon (Ravera, 2000). Fine sediments in the inner lagoon are mainly resuspended by wind generated waves and then transported by the tidal currents (Ferrarin et al., 2010). If excessive loads are discharged into the lagoon, the risk is that the lagoon would become buried in a sense and its transition from lagoon, to saltmarsh, to dry land would occur (Ravera, 2000).

The lagoon that we know today, is vastly different than the lagoon that existed when the historic city of Venice was first envisioned, and it will only continue to change. In the present, most rivers that earlier deposited freshwater and sediments into the lagoon have been diverted, progressive urbanization is rapidly expanding along the lagoon and its drainage basin; and various intertidal areas, namely Porto Marghera, are actively being filled in order to encourage the development of industrial areas (Suman, Guerzoni, & Molinaroli, 2005). (Suman, Guerzoni, & Molinaroli, 2005). These characteristics of the lagoon will be explored further in the *Threats to the Lagoon* portion of the paper.

2.2.3 Habitats of the Venice Lagoon

In searching for the right metaphor to encapsulate this complexity, where better to look than on the island of Murano. Murano, located in the Venice Lagoon, is famously known for the beautiful glass making art that can be found in the various glass factories that can be found on the island. These blown glass works of art are known for containing a kaleidoscope of colours, that come together to typically form flora- or fauna- inspired creations. The fascinating intermingling of distinct colours found in these pieces of art, can analogically be found in the mosaic like geographic structure of the Venice Lagoon. Academics refer to the Venice Lagoon as a mosaic— it is characterized by a collection of distinct and yet intermingling geographic and ecological structures such as shallow habitats that include salt marshes, seagrasses beds, intertidal and subtidal mudflats — all of which are intersected by a network of channels that branch off from the three inlets that connect the lagoon to the Adriatic Sea (Rova, Müller, Meire, & Pranovi, 2019).



(Rova, Müller, Meire, & Pranovi, 2019).

The image above presents a detailed map of the lagoon that identifies the various morphological sites found within the system including: subtidal flats, channels, intertidal mudflats, salt marshes, land, and “valli da pesca” (fishing valleys). The Venice Lagoon can be considered a system with heterogeneous morphology as it contains a complex combination of major and minor channels, salt marshes, tidal flats and of course, islands (Rova, Pranovi, Müller, 2015). The lagoon is characterized by its various morphological sites such as the channels, tidal creeks, artificial waterways and canals, that are listed. Given that there is an abundance in the variety of morphological sites found throughout the system, it is natural to note that these equate to various habitats for the species that reside within the lagoon. The collection of homogeneous habitats scattered throughout the lagoon intertwine together to form a mosaic-like heterogeneous ecosystem complete with seagrass beds, sand flats, mud flats, and salt marshes. Due to the importance and complexity of these structures, a brief overview of the morphological features and the habitats that they provide will now be discussed. One habitat in particular that must be addressed when discussing the Venice Lagoon are seagrass beds.

2.2.3.1 Tidal Flats

As can be noted in the map of the Venice Lagoon above, a massive portion of the lagoon contains subtidal flats (with bottom elevations at ca. -0.50 to -2.5 m below mean sea level (msl)), which is vegetated with seagrasses in some places (da Mosto *et al.*, 2020). The alternating advances and retreats of seawater along coasts are referred to as tides, whereas tidal flats explicitly refer to areas on which tides flood and expose low areas along the coast (Libretexts, 2020). There are three classifications of tidal flats (also referred to as mudflats): supratidal, intertidal, and subtidal (Libretexts, 2020). That part of the coast permanently submerged below the low-water line is known as *subtidal*. In subtidal areas, sediment transports are significantly influenced by transport mechanisms, erosion, and deposition (accumulation) (Libretexts, 2020). Additionally, these typically shallow marine ecosystems are largely regulated and influenced by water-level fluctuations (Libretexts, 2020). Typically, grain size in subtidal environments range from medium sized sand to clay, and because of the sediment size in these environments, suspension transportation of these sediments is incredibly important. As flow intensity into the environment increases, sediments are then able to become suspended within the water column; and then through flow or tides, these sediments can be moved (Libretexts, 2020). Any interruption to flow or tide within these environments significantly influences and restricts sediment transport which — as will be discussed in the *Threats* portion of this paper — can pose additional hazards to the wellbeing of the ecosystem. Additionally, stress can be added to the system in the form of excessive erosion and deposition due to increasing and decreasing flow of tides within the system which, if extreme enough, could threaten to alter the morphological structure of a lagoon (e.g. create new sand bars, dunes, or tidal flats) or redistribute sediments to other areas of the system that are not in need of them (Libretexts, 2020).

Intertidal mudflats are located sporadically throughout the lagoon and range from -0.5 to 0.0 m below msl (da Mosto *et al.*, 2020). This particular classification of tidal flat means that these designated parts of the coast emerge during low tide events; however, they submerge in water during high tide (Libretexts, 2020). Mudflats and the creeks that can be found in these shallow lagoon habitats are characterized by muddy bare bottoms in which seagrass vegetation is absent, but macroalgal coverage may be present (Franco *et al.*, 2006 b). These habitats function as a nursery area and feeding ground for lagoon fish fauna (Franco *et al.*, 2006 b).

2.2.3.2 Salt Marshes and Seagrass Meadows

Salt marshes are also located throughout the lagoon at +0.1 and +0.6 m above msl (da Mosto *et al.*, 2020). Aquatic habitats with muddy bottoms, such as the aforementioned tidal flats and salt marshes, are typically located around internal areas of the lagoon where freshwater inputs are more dominant and impacts from waves are minimal, therefore far from the outer sea inlets (Franco *et al.*, 2006 b). Similar to mud flat habitats, salt marshes are low-lying areas that are largely protected from wave actions; however, they are still significantly influenced by tidal changes (Webb, 2020). These sites have experienced extreme and varied human impacts that range from reclamation, waste disposal and livestock grazing, as well as restoration efforts that have been dedicated to attempting to re-establish the vast amount of salt marshes that have been lost throughout the history of the lagoon (Sarretta *et al.*, 2010). In the Venice Lagoon, the total area of salt marshes has decreased from 12,000 ha to less than 4300 ha from 1900- 2015 due to reclamation, erosion, natural and human-induced subsidence (Scarton & Montanari, 2015). Salt marsh habitats are important coastal lagoon habitats for numerous invertebrates, birds, and juvenile fish (Webb, 2020). Therefore, the destruction of these sites has immeasurable impacts on the well-being of various fauna that may depend on them.

Creeks found in salt marshes and seagrass beds are referred to as ‘structuring habitats’ and the prevalence of these habitats directly influences the fish assemblage composition of the Venice Lagoon as they supply the demand for ecological niches for various fish fauna (Franco *et al.*, 2006 b). Seagrass beds or meadows are characterized by high fish abundance and biomass, particularly when compared with the unvegetated lagoon habitats (Franco *et al.*, 2006 b). The high structural complexity offered by seagrass beds allows them to provide protection from predators and food resources that would otherwise not be found within the lagoon. In comparison to mudflats and salt marshes, seagrasses and sand flats tend to be located closer to sea inlets and deeper canals within the lagoon where grains of sediment tend to be coarser (Franco *et al.*, 2006 b). Seagrass meadows are found in the Central and Southern sub-basins of the lagoon. Salt marshes and seagrass beds are also both known for their ability to perform carbon sequestration, an extremely valuable resource for climate regulation. The 4,300 ha of salt marshes are estimated to have a sequestration rate 1.32 tons of carbon per hectare per year (da Mosto *et al.*, 2020). The 4,200ha of seagrass beds are estimated to have a rate of 40.1 tons of carbon per hectare per year (da Mosto *et al.*, 2020).

Also, ‘Valli da pesca’ refers to semi-enclosed basins for aquaculture which are located at the borders of the lagoon as well as land surfaces (consisting of supratidal sandbars, ‘casse di colmata’ (i.e. land reclamations left to renatuaralise) and settled islands) (da Mosto *et al.*, 2020). Finally, in 1989, the Valle Averte (5 km²) a State Natural Reserve, was designated as a Ramsar Site (Wetland of International Importance) a designated protected area within the Lagoon (Suman, Guerzoni, & Molinaroli, 2005). The site is an important feeding area for many species of aquatic birds and is a stopover for various migratory waterfowl — the site regularly hosts over 20,000 individuals. Additionally, aquaculture activities utilize about 3 km² of the site. (Suman, Guerzoni, & Molinaroli, 2005).

2.2.4 Species

This section briefly discusses the various species residing in order to provide further examples of ecological dynamics present within the system. As will be noted, there are various migratory species that utilize multiple areas within the lagoon and depend on the ecological mosaic that the lagoon offers. These species are evidence for the need for environmental management practices to consider the lagoon as a whole.

2.2.4.1 Fish

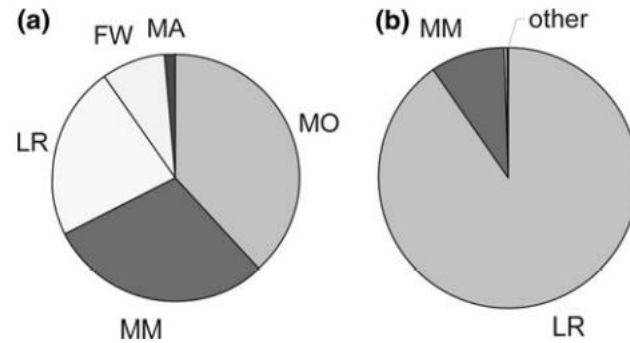
Coastal lagoons such as the Venice Lagoon are used by various fish species as nursery sites, migration routes, feeding and breeding areas — it is for these reasons that such ecosystems represent important environments (Malavasi et al., 2004). Fish fauna in particular are considered to be an important component of the biodiversity for transitional waters ecosystems (Franzoi, Franco, & Torricelli, 2010). The complex arrangement of different habitats that can be found throughout the Venice Lagoon (e.g. seagrass meadows, saltmarshes, and tidal flats) and the presence of gradients in the chemical composition of water (salinity gradients) and hydro-morphological components of the lagoon can be defined as a *spatially heterogeneous area* that can be perceived and described as *a mosaic of homogeneous elements*— in other words patches of distinct areas that come together to form an ecosystem (Scapin, Zucchetta, Sfriso, & Franzoi, 2018). It is assumed that the observed distribution of faunal organisms within the Venice Lagoon, could be influenced by the mosaic like composition and spatial configuration of the various habitat patches (Scapin, Zucchetta, Sfriso, & Franzoi, 2018). Due to the variability that the lagoon offers, species are able to exploit different resources— throughout their lifecycle they are able to disperse larvae in habitats best suited for nurseries, while also remaining able to

access resources from alternative habitats to meet their needs (Scapin, Zucchetta, Sfriso, & Franzoi, 2018).

The multifaceted morphological characteristics of the lagoon offer a diverse range of habitats for species to call home. The diversity of fish fauna found throughout the Venice lagoon is supported by this environmental complexity, which is expressed spatially by the network of interconnected habitats located along the shallows of the lagoon. Fish species in transitional water ecosystems, such as coastal lagoons, are often divided into categories based on: their physiological tolerance to variables within the environment (such as temperature and salinity); the different types of migratory and reproductive behaviors that they may express; and finally different ways individuals may use the environment (e.g. breeding or feeding) (Franzoi, Franco, & Torricelli, 2010). A paper authored by Franzoi, Franco, and Torricelli (2010) identified the various categories of fish fauna that are found in the Venice Lagoon and classified each species within these categories. These classifications are reminiscent of the ecological guilds established by Elliott and Dewailey (1995) The classifications that will be referenced include: lagoon residents (LR), marine migrants (MM), marine stragglers (MO), anadromous migrants (MA), and freshwater species (FW) (Franzoi, Franco, & Torricelli, 2010).

The Venice Lagoon is called home by at least 80 species— most studies focused on identifying species within the region have focused on the lagoon's shallow waters as they tend to be the most common habitat. Therefore, often species lists are not exhaustive: there are many other species that depend on the system, however their presence is more sporadic and infrequent. The classification of species according to the categories previously listed and corresponding number of species found within the Venice Lagoon is as follows: marine stragglers — 32 species (the most abundant category), followed by marine migrants — 24 species, and lagoon residents — 17 species (Franzoi, Franco, & Torricelli, 2010). Only one species of anadromous (moving from sea to free water to breed) migrants was identified, the twaite shad (*Alosa fallax*) (Franzoi, Franco, & Torricelli, 2010). In terms of locating these species, the LR species were found to be most numerous in shallow lagoon habitats where they totaled approximately 90% of the total fish abundance within these habitats (especially during late spring and early autumn months) (Franzoi, Franco, & Torricelli, 2010). The second most abundant group, marine migrants, show

seasonal peaks of abundance, while the other categories (MO, FW and MA) visit the lagoon infrequently, with extremely low abundance values (Franzoi, Franco, & Torricelli, 2010).



(Franzoi, Franco, & Torricelli, 2010).

The graph above represents the proportional distribution of the various species classifications found within the Venice Lagoon based on the study conducted by Franzoi, Franco and Torricelli (2010). Figure A represents the number of species found in shallow water habitats, whereas B demonstrates the abundance of each category (Franzoi, Franco, & Torricelli, 2010).

2.2.4.1.1 Lagoon Residents

The lagoon resident (LR) category groups fish species that are able to or spend their entire life cycle, or at least a majority of it, residing within the lagoon environment. LR species have expansive tolerances to variables within an environment and therefore are able to adapt to frequent changes in salinity and temperature which often characterize coastal lagoons (Franzoi, Franco, & Torricelli, 2010). In the shallow lagoon habitats, the most abundant LR species are the sand smelt (*Atherina boyeri*), two large-sized and three small-sized gobies (grass goby *Zosterisessor ophiocephalus*, black goby *Gobius niger*, and marbled goby *Pomatoschistus marmoratus*, lagoon goby *Knipowitschia panizzeae* and black-spotted goby *Pomatoschistus canestrinii*), a pupfish (*Aphanius fasciatus*), and three pipefish species (*Syngnathus abaster*, *S. typhle*, *Nerophis ophidion*) (Franzoi, Franco, & Torricelli, 2010).

The two of the three pipefish species mentioned earlier (*Syngnathus typhle* and *Syngnathus abaster*) dominate seagrass habitats and have been accounted for making up approximately 64% of the total number of individuals caught in this habitat (Franco *et al.*, 2006 a). As mentioned, the most abundant LR species is the sand smelt (*Atherina boyeri*) individuals from this species has

been documented as abundant across all habitats within the lagoon (Franco *et al.*, 2006 a). The sand smelt is not found exclusively in shallow areas, it can be found anywhere from around the sea inlets, to deep within the lagoon— this is unique to this species as the majority of lagoon species require specific habitat characteristics (Franco *et al.*, 2006 a). For example, various species are all reliant on particular habitats such as the rocky bottoms and seagrass meadows found within the lagoon (Franzoi, Franco, & Torricelli, 2010). While the sand smelt may be the most abundant LR species, the marbled goby (*Pomatoschistus marmoratus*) is the dominant taxon span from 42-63% in abundance in habitats within the lagoon (Franco *et al.*, 2006 a).

2.2.4.1.2 Marine Migrants

Marine migrants (MM) are marine spawning species in that they periodically visit the lagoon in order to produce eggs— these visits are referred to as migrations. These migrations can be ontogenetic in that they occur at a particular phase or time within the lifecycle of a species, or cyclical (e.g. seasonal visits) (Franzoi, Franco, & Torricelli, 2010). The MM category can be further broken down to classify marine seasonal migrants (MS) as well as juvenile migrant species (MJ) which are the species that most typically perform ontogenetic migrations (Franzoi, Franco, & Torricelli, 2010). These species may engage in several migration cycles between the lagoon and the Adriatic, throughout their lifetime. For example, certain MJ species spawn in the Adriatic, but then spend the juvenile phase of their life cycle in the Venice Lagoon in which cases the shallow water habitats become intensely populated by these species. Approximately ten MJ species are commonly observed in the lagoon (Franzoi, Franco, & Torricelli, 2010) (Malavasi *et al.*, 2004). The grey mullets are most abundant in unvegetated saltmarsh creeks (*Liza ramada*) as well as in sand habitats — although the species *Liza aurata* and *Mugil cephalus* are restricted to sand habitats whilst in the lagoon (Franco *et al.*, 2006 a). There are approximately eight MS species that seasonally visit the lagoon (Malavasi *et al.*, 2004). The European anchovy can be found in habitats all across the lagoon however it is most prominently located in unvegetated mudflats and sand habitats (Franco *et al.*, 2006 a).

2.2.4.1.3 Marine Stragglers

Marine stragglers (MO) are a marine spawning and stenohaline species (tolerant of salinity fluctuations), that are found in transitional waters irregularly due to the fact that they do not depend on the system or specific resources within the system for survival in any of their life stages. These species visit sporadically, and when sited they tend to be few in number and

largely in areas of the system most exposed to marine influence such as the areas around three sea inlets that have submerged vegetation (Franzoi, Franco, & Torricelli, 2010). (Franzoi, Franco, & Torricelli, 2010). A study by Malavasi et al. (2004) conducted an analysis of fish assemblage in the Venice Lagoon, they identified 13 marine adventitious visitors — species that appear regularly but do not require resources provided by the lagoon— equivalent to the classification of MO species (Elliott & Dewailly, 1995). Approximately thirteen of these species occur in the lagoon (Malavasi *et al.*, 2004).

2.2.4.1.4 Freshwater Species

Freshwater species (FW) are species that occur infrequently in transitional waters such as lagoons— however there are often few species and few individuals of this nature in these systems. They are typically located in the *oligohaline zone* of coastal lagoons, which refers to areas of low salinity such as the sources of freshwater inputs to the lagoon such as the Dese River mouth in the Northern lagoon sub-basin (Franzoi, Franco, & Torricelli, 2010). Due to the dependence of freshwater inputs to provide a habitable environment, the presence of these fish is generally tied to the seasonal variances found in river flow (Franzoi, Franco, & Torricelli, 2010). It has been noted by various fish assemblage studies that there are few occasional freshwater species that visit the lagoon such as the brown trout (*Salmo trutta*) (Malavasi *et al.*, 2004). Due to seasonal variations in fish assemblage and study sites selected by academics the species listed above are not exhaustive of all that can be found within the Venice Lagoon. The variations within assemblage and challenges in collecting an exhaustive species catalogue further demonstrates the complexity of the Venice Lagoon System, and the intense scrutiny environmental managers should apply when assessing impacts of lagoon health on fish inhabitants.

2.2.4.2 Crustaceans and Mollusks

Seafood is not only an important source of nutrients and sustenance in many countries, it can also significantly contribute to the cultural identity of the region. Aside from cuisine, these species also hold numerous invaluable functions that aid the ecosystems that they reside in. Some crustacean species that have been observed in the Venice Lagoon Mediterranean include the green crab (*Carcinus aestuarii*), Caridean shrimps (*Crangon crangon*), scampi (*Nephrops norvegicus*), various members of the shrimp genus *Palaemon spp.*, deep-water rose shrimp (*Parapenaeus longirostris*), as well as a species of mantis shrimp (*Squilla mantis*) (Caburlotto,

2016). In 1983 the invasive manila clam (*Tapes philippinarum*) entered the lagoon. The implications of harvesting this species will be discussed further in the *Threats* to the lagoon section of this paper (Pranovi *et al.*, 2003).

2.2.4.3 Birds

Artificial tidal sites, or islands are created by the controlled disposal of sediments that have been dredged from sea inlets, channels, and lagoons — these human-made islands provide nesting, resting and feeding habitats for many birders. Based on 32 ornithological surveys from 2009-2010 that were conducted on six artificial intertidal sites located in the Venice Lagoon. 101 species of birds were observed, with 58 of these species flagged as a conservation concern (Scarton & Montanari, 2015). Ducks (2 species), waders (22 species), herons (8 species), passerines (43 species), gulls and terns (9 species) are some of the most observed species within the Venice Lagoon. Due to migration, breeding, nesting, and feeding behaviours the number of waterbirds species present in the lagoon varies. For example, in Scarton and Mantanari's (2015) study, in post breeding seasons 86 species were observed, during pre-breeding migration and wintering season 51 species were noted, and least abundant season was nesting season in which 45 species were present. The Venice Lagoon also functions as one of the most important wintering sites in the Mediterranean as a study noted that from 2006-2010 the site hosted 350,000 waterbirds in mid-January (Scarton & Montanari, 2015).

2.3 Threats to the Lagoon

It has been mentioned numerous times throughout this paper that the Venice Lagoon is a complex, yet delicate system. This complexity has been heightened by the combination of past interventions, physical functions, and ongoing activities that occur within the lagoon that are held responsible for instigating several issues that severely threaten the health of the lagoon ecosystem (Rova, Pranovi, Müller, 2015). Despite the human interventions that have been implemented over a millennium in order to 'save the city', today Venice is a site of serious environmental degradation, high risk of coastal hazards, and an absence of sustainability. The Venice Lagoon has seriously deteriorated, especially within the last century, after the development of Porto Marghera for industrial uses as was discussed earlier (Ravera, 2000). Activities such as the draining of mudflats for construction and agriculture, as well as the dredging of channels to accommodate maritime shipping, have both severely disturbed the

lagoon's relationship with the sea and increased pollution within the area (Suman, Guerzoni, & Molinaroli, 2005).

The ongoing activities of dominant economic stakeholders and policymakers support behaviour patterns that are based on high, short run profit objectives which are devastating the Venice lagoon environment (da Mosta *et al.*, 2020). These patterns have generated both short and long-term costs and benefits that range from socio-cultural, such as the simultaneous rise of city congestion and depopulation, to the environmental — including but not limited to: air pollution, land degradation and damage to building foundations by boat wakes and lagoon erosion (da Mosta *et al.*, 2020). Earlier in this paper, various complexities of the lagoon were discussed and mentioned as geographic or ecological factors that could threaten the long-term environmental integrity of the lagoon. The next section hopes to identify the activities or ecological and geographical processes that threaten to dismantle the lagoon ecosystem, in order to provide greater context to the challenges within the region. While no doubt these activities and threats risk grave impacts to the system, they also pose extreme challenges to resource management within the region, which has to consider a variety of stakeholders, while remaining sustainable in order to ensure the survival of the historic city.

The main focus of this paper is on analyzing water management frameworks within the lagoon, identifying potential solutions to encourage nature-based management practices, and provide insight to the thoughts and expectations of stakeholders in the region. This portion of the paper is lengthy, but this is to demonstrate the obstacles and nuances that these governing and protecting documents must respect in order to ensure that a complete understanding of the system is encouraged and valued in decision making processes and in governing documents.

2.3.1 Anthropogenic Activities: Clams, Tourism, and Cruising for an Ecological Bruising

Human interventions and industry developments of the past and present have caused the loss of natural habitats such as woodlands and freshwater wetlands, which were once present along the borders of lagoon and acted as a “green belt” not unlike those surrounding many metropolitan cities around the world (Suman, Guerzoni, & Molinaroli, 2005). The disappearance of this protective green area has produced two notable detrimental impacts to the region — first being the disappearance of flora and fauna and second the decrease of the self-purifying capacity of the ecosystem with respect to nutrients (Suman, Guerzoni, & Molinaroli, 2005). The list of

negative human impacts on the Venice Lagoon ecosystem is extensive. This section hopes to review the most cited threats determined from anthropogenic activities.

2.3.1.1 Tourism

Today globally, tourism is one of the leading problems facing cities. It wields a double-edged sword, one side bringing in extensive revenue by appealing to the needs of tourists; the other affecting the primary needs of citizens and threatening to ruin the ecological integrity of places so beautiful that individuals spend thousands of dollars to visit them. Such impacts have occurred in historic cities such as Barcelona, Prague, and of course Venice which in 2017 received an average of 60,000 visits per day (Seraphin, Sheeran, & Pilato, 2018). Venice in particular has been put up against the double-edged sword, as many of the city's citizens, and its environment, face a losing battle. The city and its decision-makers seem to favour the demands of the tourists (González, 2018). There has been an increasing rise in anti-tourism sentiment across Europe, most notably in Spain and in Italy as large numbers of annual tourists are placing immense pressure on the environmental sustainability of these destinations and creating conditions that overall decrease the quality of life for locals (Seraphin, Sheeran, & Pilato, 2018). There are numerous studies available dedicated to analyzing tourism in Venice and its impacts on the lagoon, local economy, and the city's global position. For brevity, here are some of the major adverse impacts posed by tourism activities in the region: vandalism, pollution (visual, plastic, fuel, chemical contaminants), air emissions, sewage releases, destruction of historical sites (Seraphin, Sheeran, & Pilato, 2018)(Cecchi, 2021). Plastic marine litter is one of the most notable and visible impacts from tourists—and microplastics are fully capable of leaching into our water ways and are an increasing concern for environmental health. A study by Cecchi (2021) analyzed changes in pollutants at the molecular level due to the halt in tourism as a result of the Covid-19 global pandemic. The study observed that over 40% of volatile contaminants that were identified in a high tourist season in 2019 had disappeared from the Venice Lagoon after the lockdown period (Cecchi, 2021).

2.3.1.2 Large Vessels

In 1987, Venice and its Lagoon was recognized as a single entity when both were added to the UNESCO World Heritage list (Seraphin, Sheeran, & Pilato, 2018). However, it is thought that this designation over time has evolved from a significant marker advocating for the preservation and conservation of the unique and magnificent site to a brand that countries can

use as a marketing tool to attract tourists, and in turn tourists use this brand to help them identify noteworthy destinations to which they may wish to travel (Seraphin, Sheeran, & Pilato, 2018). Riding in gondolas, taking the water taxi, traveling the Italian coast via cruise ship, etc., are experiences that are on many travelers' "bucket lists". While the auto industry receives justified scrutiny over its environmental impacts, the same scrutiny should be applied to emission-based or intense vessel wakes.

At Venice's height of dominance as a maritime superpower, the city was frequently referred to as the "Queen of the Seas". As discussed in the brief historic background to the region, during the late medieval period the Port of Venice was a focus of the then "global" economy due to its vital position as a connecting port between the Middle East, the Mediterranean coasts and continental Europe. Venice's growth and power as a thriving trading place was attributed to the accessibility of the docks. In 1922 the canal was extended from Stazione Marittima to the Porto Marghera Industrial Zone (PMIZ) and for four decades, the route to the PMIZ passed through the historic centre of Venice, which provided pressure on the city due to traffic (Scarpa et al., 2019). This pressure was then reduced by the creation of a new waterway, the Malamocco–Marghera Channel (MMC) through the central lagoon, in the late 1960s (Scarpa et al., 2019). After the opening of the MMC, industries residing in Marghera expanded and the Venice port showed its relevance with about 3500 port calls (Scarpa et al., 2019) per year. Of these ships, approximately 3000 are commercial vessels, with the remaining 500 classified as cruise ships, travelled through the Lido inlet (Scarpa et al., 2019). So, since the original creation of the Port of Venice, ship size and traffic within the region has increased, leading many scholars to wonder about the adverse impacts that may result from this industry such as pollution, or erosion from ship wakes.



Personal image of an anti-large vessel sign in Venice

Currently, Venice is one of the most active cruise ports in Southern Europe receiving (in a regular season) several hundred ship visits whilst carrying approximately one million passengers annually (Seraphin, Sheeran, & Pilato, 2018). As cruise ships move along the quays close to the San Marco area, this nearby traffic has created a strained relationship between the port and city authorities. The port authority would like to redirect the passenger traffic, but many businesses and industries within the community wish to safeguard the direct flow of tourists to the center undisturbed by regulation (Seraphin, Sheeran, & Pilato, 2018). One may ask, what would the benefit be to redirecting cruise ship traffic? The answer lies in the damage that vessel wakes can impose on shallow coastal environments.

Vessel wakes refer to the waves produced by the momentum of ships. These can range in size in accordance with the speed and size of the vessel in question. Vessel wakes generated in open sea areas are able to disperse and decay rapidly as they increase in distance from the ship—the ability to disperse the impact of the wake over open waters prevents adverse impacts on seabed, nearshore areas, and ecosystems (Scarpa *et al.*, 2019). However, a different story is told in shallow coastal areas and narrow waterways, in which there are minimal waters for wake impact to lessen. Studies have shown that ships sailing at moderate speeds in shallow areas or channels are still capable of instigating disturbances such as dangerously high leading waves,

depression areas, as well as steep and short waves (Scarpa *et al.*, 2019) (Henn, Sharma, & Jiang, 2001). These waves not only threaten the safety of smaller vessels, they also have the potential to severely damage the integrity of the coastal environment they sail in. For example, depressions originating in Venice Lagoon channels instigated by ships have the potential to transform into strong deep waves that can spread long distances across the lagoon bringing with them large amounts of sediment (Scarpa *et al.*, 2019) (Rapaglia, *et al.*, 2011). As articulated earlier, there are expansive tidal flats on one or both sides of the navigational channels within Venice Lagoon (Scarpa *et al.*, 2019). The extensive sections of tidal flats in the waterway encourage the far-reaching impacts from ship traffic that were warned of earlier. This feature poses potentially extreme risks to the bottom and coastline of the Venice Lagoon (Scarpa *et al.*, 2019).

After the opening of channels, developments within Marghera, increases in ship size, and traffic a pattern emerged. An ecological problem would present itself, humans would adapt to it, and additional demands or pressures would be placed upon the environment and additional innovation is required. Since the opening of the MCC and the overall growth in port traffic, the morphological structure of the lagoon has drastically changed. Studies observed that the central lagoon basin experienced extensive erosion from 1970 to 2000 (-0.80m to -1.80m) (Scarpa *et al.*, 2019). Previously, scholars attributed this severe erosion to changes in the overall hydrodynamic regime of the lagoon which resulted from the introduction of the new channel. However, recent studies remarking that at some of the erosion was caused explicitly by ship traffic (Scarpa *et al.*, 2019) (Zaggia *et al.*, 2017).

Adopting the findings from recent academic literature, it should not be unexpected that the bottom, shores, edges of channels, and in general the entire ecosystem of the Venice Lagoon has suffered at the hands of wave propagation and erosion induced by ships operating within the system. What is worrisome for those hoping to conserve the lagoon are the pragmatic predictions that traffic and ship size within the industrial channel are only expected to increase in the future. These actions would only heighten concerns regarding the impacts the system experiences due to cruise ships traversing through the Venice Lagoon dangerously close to the historic city center (Scarpa *et al.*, 2019).

“Venice faces a difficult choice between its role as a port city and protection of the lagoon and its unique cultural heritage as the large scale and intensity of port traffic

combined with the effects of navigation through a shallow lagoon are a severe threat to the integrity of the lagoon ecosystem” (Scarpa et al., 2019, p. 3).

As it has been mentioned throughout this paper thus far, the fate of the city of Venice has always depended on the functionality of the ecosystems that surround it. These systems are already facing severe challenges and therefore it is crucial that we work towards understanding and managing the interactions between ship traffic and the environment when in pursuit of sustainable management of the Venice Lagoon.

2.3.1.3 *Clam and Mussel Cultivation*

From one aquatic tyrant to the next, clam and mussel cultivation are important activities within the lagoon. It must be noted that often illegal fishing techniques are utilized by an additional 100 vessels that are dedicated to the fishing of manila clam (Suman, Guerzoni, & Molinaroli, 2005). Until the end of the 1980s, natural resources were exploited solely through artisanal fishery; however, since the 1983 invasion of the manila clam, clam harvesting has become the main exploitative activity within the region (Pranovi *et al.*, 2003). Since the 1990s, manila clams have been harvested by using mechanical dredges — in 2003 approximately 600 ships were using dredging mechanisms to collect clams; with demand it is expected this number may have increased (Pranovi *et al.*, 2003). Currently more than 50% of clam production within Italy comes from the Venice Lagoon and academic projections state that harvesting practices will continue to operate in restricted areas until the target species (manila clams) has been reduced to such a level that exploitation is no longer economically viable (Pranovi, Da Ponte, Raicevich, & Giovanardi, 2004). While concerns about the costs of over-exploitation in the economic sector are valid, it is critical that the ecosystem is also considered when assessing the impacts over over-exploitation.

These dredges consist of a gear referred to as “rusca” which forcefully applies water flow onto the sediment in order to suspend bottom sediments and clams into a plume in the water so that clams and other invertebrates can be collected in nets by local fishers (Pranovi, Da Ponte, Raicevich, & Giovanardi, 2004). Direct removal, damage, displacement, or death of a proportion of benthic organisms, which occurs when bottom sediments are displaced, induces changes in the community structure of the lagoon (Pranovi, Da Ponte, Raicevich, & Giovanardi, 2004). It is important to note that single instances of rusca fishing are insufficient in producing detectable

alterations to sediment grain size; however, the main concerns are with regard to repeated suspension events and how they may impact the ecosystem over time (Pranovi, Da Ponte, Raicevich, & Giovanardi, 2004). Rusca fishing does impact the distribution of organic carbon in sediments and the concentration of suspended particulate matter which in turn influences species within the lagoon—aside from the targeted clams that are being harvested (Pranovi, Da Ponte, Raicevich, & Giovanardi, 2004). As has been alluded to in previous portions of this paper, and will be discussed later in this section, sediment movement is a fragile issue within shallow coastal lagoons, and therefore any activity that impacts this distribution needs to be monitored to ensure that catastrophic adverse impacts are not sustained from these actions.

2.3.2 Climate change and Sea-Level Rise

In order to understand how climate change may impacts the Venice Lagoon specifically, it is crucial to understand what effects climate change may have on marine and coastal systems. As mentioned earlier, the Venice Lagoon is an ecotone, in other words a transitional area. Transitional areas such as lagoons are among some of the most impacted and delicate environments threatened by both climate change and human action, as even small-scale actions can lead to damaging rippling effects that can suddenly or severely alter the fragile system (Bellafiore et al., 2014). Climate change, as defined by the IPCC (2019) is ‘a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer’. A 4th report produced by the IPCC states that there is an expectation for global temperature change from 0.3 °C and 6.4 °C from 1990 to 2100 depending on various emission scenarios (IPCC, 2019). During this time period, sea levels are also expected to rise approximately 0.18m to 0.59m (IPCC, 2019).

Global warming can cause rising sea levels in two ways. First, as the ocean warms it increases in size taking up more space — this phenomenon alone has contributed to half of the sea level rise within the past century (Amadeo, 2020). Secondly, increasing temperatures exacerbate the melting of Greenland’s ice sheets as well as the polar ice caps (Amadeo, 2020). Between 2002 and 2016 Antarctica lost 125 gigatons of ice annually which consequently resulted in 0.013 inches of sea level rise per year (Amadeo, 2020). Antarctica alone holds 90% of the world’s ice — should it melt, sea levels would rise approximately 200 feet. Rise in sea-levels threatens to increase the occurrence and severity of flooding events (Amadeo, 2020).

Additionally, coastal lagoons are sheltered environments that are ideal for juveniles of various species, some of which are economically influential. The primary productivity of coastal lagoons also encourages and support abundant communities of animals. Rising sea levels already risk overwhelming lagoons globally; however, it can also lead to light limitation which in turn would degrade a lagoon's microphytobenthos community, increase nitrogen fluxes and trigger eutrophication (Brito, 2012). Symptoms of climate change risk permanently altering the quality of water and the balance of organisms within lagoons. Lagoons host numerous valuable ecosystem services responsible for regulating and defining the functions of these systems, such as: nutrient cycling, nutrient fluxes, acting as sinks for sedimentation particles and as a buffer for the land-sea interface (Brito, 2012).

Furthermore, the global temperature increase is expected to alter hydrological cycles and increase precipitation across northern and central Europe (IPCC, 2019). Extreme events such as storms are also predicted to increase in severity and regularity as a result of climate change. Coastal communities globally can expect to be exposed to multiple climate related hazards such as: tropical cyclones, extreme sea levels and flooding, marine heatwaves, extreme waves, coastal erosion, acidification, salinity intrusion, loss of coastal infrastructure, and loss of biodiversity (IPCC, 2019). The overwhelming influence climate change can and will have on coastal environments is alarming. Therefore, it is critical that research dedicated to understanding these impacts at local levels occurs so that residents, stakeholders, and decision makers can make the appropriate responses to protect the lands— or waters — that they depend on.



Personal image of Venetian street art portraying Van Gogh under water symbolizing the inundation of art throughout the islands

Lagoons traditionally have short lifespans— on geological scales — due to the already mentioned fact that they typically evolve to dry land or become marine bays (Ravera, 2000). However, in the case of the Venice Lagoon, human interference has managed to successfully prolong the life of the system, despite what nature has thrown its way. Coastal lagoons are exceptionally vulnerable to the effects of climate change. As discussed, a critical symptom of climate change for coastal environments is sea level rise. However, another natural function of lagoons is that they can act as sediment or solid material sink for discharges carried by the lagoon's tributaries. These two threats— becoming a marine bay or transitioning to dry land— would devastate the existing functions of the lagoon and these are processes that climate change is accelerating, especially in the Venice Lagoon. For this reason, this next section will analyze the Venice Lagoon, its eminent evolution, and the looming threat of extreme weather events. Additionally, to properly understand the effects of the hydrological changes that climate change may incur on the Venice Lagoon, it is also critical to remember the unique ecological structure of lagoons, which are characterised by continuous changes in the main environmental variables, such as salinity, water renewal, nutrients, turbidity and sediment structure that generate composite sea-land gradient.

2.3.3 The Evolution of the Venice Lagoon: Sink or Swim?

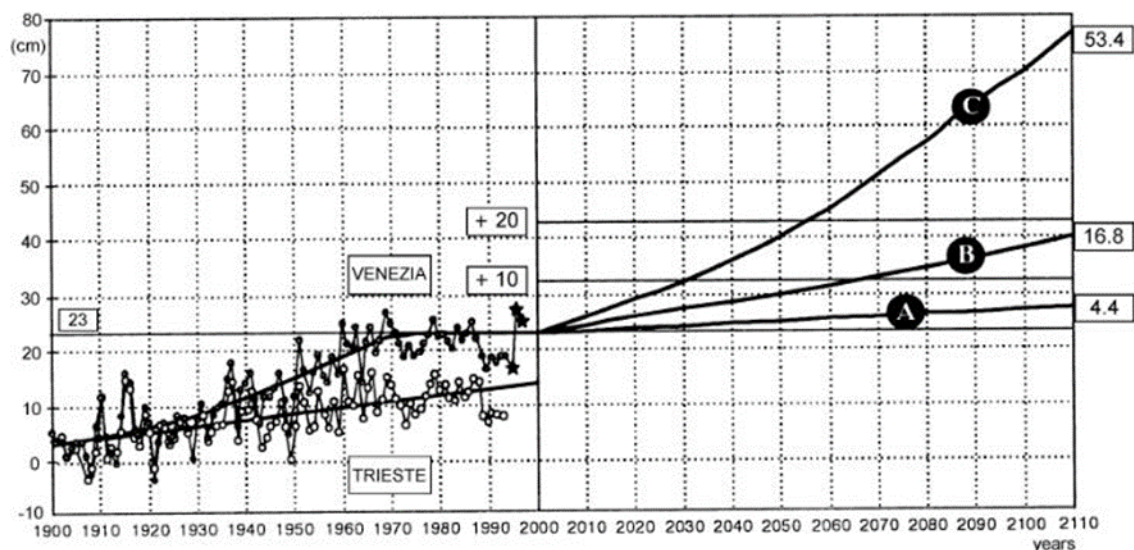
An additional variable to consider when studying the Venice Lagoon is the act of subsidence. Subsidence is the sudden sinking or gradual downward settling of the ground's surface. Many coasts along the Adriatic have been steadily sinking for years; however, solid material delivered to the coasts by rivers that flow into the Adriatic have been able to effectively distribute sediments to amply counteract the coastal lowering rate (Ravera, 2000). The changes in the morphology of the Venice Lagoon during the last century result from sedimentological responses to the effects of human interventions on the environment and global changes (Ferrarin et al., 2013). In the context of the Venice Lagoon, human interference over centuries has prevented sediment accumulation from the twelve tributaries, which means that subsidence within the region is not currently being offset (Ravera, 2000). Additionally, natural subsidence within the Venice Lagoon seems to be exacerbated by ground water and natural gas extraction within the region (Ravera, 2000). So, the risk of the Venice Lagoon evolving to a saltmarsh and then eventually transforming to dry land does not possess the immediate threat level that sea-level rise holds.

Throughout the last five centuries, sea levels have been slowly rising. This phenomenon is referred to by academics as 'eustatism' (Ravera, 2000). Eustatism poses multiple threats to the Venice Lagoon and the islands within it. Namely, when eustatism and subsidence combine, the process results in the lowering of Venice to a level that, in relation to the sea, establishes permanent risk to the overall wellbeing of the Lagoon and its islands (Ravera, 2000). The lowered level of the lagoon as a whole encourages increases in the occurrence and severity of flooding events. The Veneto region is already a flat landscape that is covered by low, dense, and heterogeneous vegetation, all of which already enable it to be frequently inundated by the tide — in the Venice Lagoon, twice a day on average (Ivajnsič et al., 2018). Should sea levels continue to rise, inundation will plague the region to a point where anthropogenic efforts can not keep up.

Additionally, should water deposits into the lagoon exceed the rate of solid loads into the lagoon, the sandbars that protect the lagoon from the Adriatic Sea would vanish and essentially the lagoon would become a marine bay (Ravera, 2000). It is estimated that when subsistence and eustatism is considered, the rise in sea level ranges from 13 to 15cm in a century (Ravera, 2000). However, as discussed, climate change threatens to exacerbate rising sea levels which adds an additional level of stress to the health and wellbeing of the lagoon. In essence, Venice Lagoon,

and its islands have two major problems knocking at their door. The lagoon is sinking, and sea levels are rising — a deadly combo that threatens to increase the frequency of flooding in Venice’s urban centre.

Venice has sunk almost 25 cm within the last century. For more than the last 50 years, industries throughout the region have pumped groundwater, a practice that—in combined with the 10cm of natural sinking due to tectonic rates— has accelerated the city’s overall subsidence (Molinaroli, Guerzoni, & Suman, 2019). Paired with an unyielding eustatic rise in sea level, subsidence has increased relative sea level rise by $\sim 1.5 \text{ mm year}^{-1}$ between 1972 and 2002 and up to 5 mm year^{-1} in the southern lagoon margin (Molinaroli, Guerzoni, & Suman, 2019). Subsidence of the lagoon has increased the frequency of flooding events (*acqua alta*) and favored sediment erosion and the increasing influence of marine processes (Molinaroli, Guerzoni, & Suman, 2019). In addition to “normal” high water periods throughout the last 20 years, ten “exceptional” events ($>140 \text{ cm}$) have taken place, during which $\sim 80\%$ of the city surface and more than half of public spaces were under water (Molinaroli, Guerzoni, & Suman, 2019).



(Ravera, 2000)

The image above demonstrates sea level rise from 1900-2000, and then elaborates to provide three separate sea level rise scenarios. Scenario A reflects a 4.4 cm rise over the next 110 years based on calculations that assume that long-term eustatism has stopped and long-term geological subsidence is the only process contributing to sea level rise. Scenario B reflects 16.8cm over the next 110 years assuming long term eustatism and subsidence will continue as they have. And

finally, Scenario C which represents a 53.4cm rise over the next 110 years contains calculations from Scenario B as well as additional sea-level rise from human induced climate change.

Generally, the lagoon has shown a distinct change in depths from a value of -0.62 m in 1927 to -0.88 m in 2002 (Sarretta et al., 2010). The most noticeable depth changes have occurred in the lagoonal sub-basins south of the city of Venice, where depth increased from -0.65 to -1.12 m in Lido, -0.64 to -1.75 m in Malamocco and -0.39 to -0.88 m in Chioggia. These massive changes to lagoon morphology have been linked to human activities that were discussed earlier: the dredging of navigation channels, and intense natural erosion that was exacerbated by sediment re-suspension due to Manila clam fishing (Sarretta et al., 2010).

As discussed previously, reports produced by the Intergovernmental Panel of Climate Change state that rising sea levels are indeed a threat that must be considered by decision-makers and included in risk calculations. Additionally, statistics collected by Ravera (2000) and other scholars demonstrate that rising sea levels are already occurring and have been for centuries — the impacts of climate change are not a future concern, they are happening now. Therefore, Scenario C, as dire as it may appear, arguably is the most accurate representation for the future of Venice. This figure effectively demonstrates that climate change's impacts on the hydrology of the Venice Lagoon needs to be understood in order to properly prepare for them.

Additionally, rising sea-levels may project adverse ecological impacts on the Venice Lagoon. As mentioned earlier, water renewal of the lagoon is maintained by the tide that cycles through the three inlets; this process is critical for the lagoon's metabolism and chemical composition (Ravera, 2000). An increase in renewal time maintained over a long period of time would increase the variation of salinity throughout the year— these variances would be further instigated by rainfall distribution, evaporation and water load deposits from the watershed (Ravera, 2000). Sea level rising may have numerous impacts on salt marsh habitats throughout the Venice Lagoon. A study conducted by Ivajnšič et al. (2018) demonstrated that nearly all habitats within the lagoon will decrease by 2050 and beyond (Ivajnsič et al., 2018). This could have devastating impacts on the overall biodiversity of the lagoon, as well as to those that depend on food provisioning ecosystem services offered by the lagoon.

2.3.4 Extreme Weather Events in the Venice Lagoon

The Venice Lagoon and Adriatic Sea is increasingly being exposed to flooding risks from storm surges which are also referred to as *acqua alta* phenomena. As previously discussed, in the last century the city of Venice faced an increase in frequency and intensity of flooding events, that periodically submerged parts of the old city centre, due to the combined effect of climate change and subsidence. However, sea-level rise from climate change is not the only concern the region faces. Massive waves that are being triggered by extreme weather conditions are also occurring more frequently (Morucci *et al.*, 2020). The largest extreme sea level events have been mostly caused by storm surges produced by the Scirocco winds. This leads to a characteristic seasonal cycle, with the largest and most frequent events occurring from November to March (Morucci *et al.*, 2020).

Most notably the October 28th-29th 2018 storms were so aggressive the Italian Civil Protection Department set off the national environmental alert. During this time, both Venice and the North Adriatic were exposed to extreme marine conditions —higher sea levels and massive waves— that were induced by extreme weather conditions (Morucci *et al.*, 2020). Essentially, low atmospheric pressure from the Western Mediterranean combined with the strong and persistent South-East wind on the Adriatic caused storm surges along the coast (Morucci *et al.*, 2020).

In November 2019, a state of emergency was declared when the main island was engulfed in 6ft high water levels, cutting power to homes across the islands (BBC, 2019). Two people died as a result of the flooding. At the time the mayor declared that climate change was the key driver for the highest water levels in the region in over 50 years. Since official records had begun, the highest tide was 1.94m in 1966 (BBC, 2019). Parts of the ancient city were left under six feet of water, including the 925-year-old St. Mark's Basilica (Hillburg, 2020).



Personal image of the flooding of Venice in December 2019

Increases in the occurrence and severity of extreme events, such as storms, are also predicted by the IPCC (2019). Therefore, the devastation shown in these examples is a sample of what is still to come. Previously it was mentioned that rising sea levels can wash away a lagoon's sandbars and thus convert the lagoon into a marine bay. Additionally, sediment levels can alter the composition of the lagoon until it eventually disappears. However, extreme events, like storm surges and massive waves, pose the same threats. Storm events can cause lagoon entrances to close by pushing sand in from the sea (Chapman, 2012). Should the sand not be removed artificially at a rate that complies with water renewal, then the lagoon can become "full" —in a sense creating a primarily freshwater lake that will one day disappear completely. This will have the same effect as excessive sediment deposits from tributaries which will bury the lagoon until it effectively disappears (Chapman, 2012).

Conversely, extreme events can result in the erosion of lagoon sedimentary barriers which would widen the entrances to the lagoon and effectively transform the lagoon into a marine bay (Chapman, 2012). These will increase the flooding risk in the lagoon system and may contribute to the rapid degradation of the ecosystem (Brito, 2012). Floods in the Venice city centre have resulted from a combination of several extreme weather events including: astronomical tides, storm surges, meteotsunamis, and surges caused by planetary waves (Lionello *et al*, 2020).

Astronomical tides in the Adriatic Sea refer to two Kelvin waves that oppositely travel along the basin as well as topographic waves that travel across the basin during a 24- hour period daily (Lionello *et al*, 2020). Meteotsunamis are meteorologically generated long waves (i.e. by violent storms) in the tsunami frequency band that pose a major hazard to the Adriatic coast (Lionello *et al*, 2020). In the Mediterranean region, cyclone activity is frequent due to a range of factors and mechanisms that promote or favor several cyclogenesis processes (Lionello *et al*, 2020). The conditions that lead to extreme storm surges at Venice are clearly documented, as they are cyclogenetically generated occurring in the western Mediterranean Sea (Lionello *et al*, 2020).

The sedimentary barriers that define coastal lagoons work extensively to protect the lagoon and its contents from the harsh blows from the aforementioned events. Should the barriers erode, the impact from these events can be devastating for both the city center as well as the ecosystems within the lagoon. Alterations to the Venice lagoon, whether it is the evolution to a marine bay, or the physical impacts from aggressive weather has the potential to devastate ecosystems within the region as well as impact those that rely on them.

Chapter 3: Ecosystem Services

3.1 Background

The earliest mentions of the concept ‘ecosystem service’ can be found in 1997 in both a book by Gretchen Daily and an article in the journal *Nature* by Constanza et al (Costanza et al., 2017). Constanza (2017) goes so far as to state that this concept could be considered as old as humans themselves. For centuries, human societies have acquired essential goods from natural ecosystems for survival — goods such as seafood, game animals, timber, and even pharmaceutical products (Daily *et al.*, 1997). It is acknowledged that natural ecosystems carry out biological processes that are fundamental in supporting the survival of the ecosystem such as air purification, regulation of climate, and waste disposal (Daily *et al.*, 1997). These characterizations of ecological and human interaction put the concept of ecosystem services on the map, and have since become a pressing topic of conversation in environmental management practices.

While these processes contribute trillions to the global economy annually, they are often over-looked and under protected because these benefits cannot be directly traded in economic markets. One cannot trade mitigating floods or droughts on the stock market, nor can one put a definite monetary value on these critical ecosystem functions. As Daily *et al.* suggest in an early work discussing ecosystem services, the fact that these ecological processes do not have a clear price tag attached to them results in that there is not an obvious alarm system that can make societies aware of subtle changes to their supply, or to the degradation of the underlying ecosystems that makes them vulnerable to overconsumption or exploitation (1997). Often, it is far too late that we begin to realize the extent of environmental degradation that has occurred due to human usage. Historically, the value and importance of Earth’s life support systems, in other words ecosystem services, are largely ignored until disruption in “business as usual” or extensive ecosystem loss has occurred (Daily *et al.*, 1997).

The Millennium Ecosystem Assessment (MEA) was established in 2005, and through the work over 1300 scientists, a framework for analyzing social-ecological systems capable of influencing policy and scientific communities was developed (Carpenter et al., 2009). MEA assesses ecosystems based on the services that they provide to society and how these services benefit humanity (Carpenter et al., 2009). Initially, ecosystem service assessment frameworks

were used to identify values with environmental benefits that are linked to human well-being and then assess whether a market existed for the benefit or not (Le, Levin, & Carson, 2017). However, discourse in sustainable development stated that the incorporation of these values into environmental regulation, regardless of whether there is a market for them, is a necessity for the sustainable management of resources (Le, Levin, & Carson, 2017). It was the MEA “A Framework for Assessment” that most significantly demonstrated the benefits of developing ecosystem service frameworks for environmental decision making that can address the ecosystem services that humans depend on, while also incorporating the often-overlooked services ecosystems offer that are critical for human societal and ecological survival. Previously, management practices focused on conserving ecosystems so they are able to uphold the services humans need; however, this new framework provides a holistic overview of ecosystems by demonstrating that the sustainable management of resources depends on the protection of all services within an ecological system (Le, Levin, & Carson, 2017).

Ecosystem services is an approach to ecosystem management that promotes an integrated and multidisciplinary approach to resource management, conservation and protection — especially in complex ecosystems. Ecosystem services assessment (ESA) mechanisms allows for a more comprehensive overview of the desired region and can therefore correctly assess the boundaries of exploiting the region as well as defining the parameters or protection needed to ensure the ecosystem can survive human interference. Therefore, given the complexity of the Venice Lagoon, and the various actors that have taken interest in the well-being and services the lagoon offers, ESA’s are an environmental management approach that can best reflect the needs and attributes of the system.

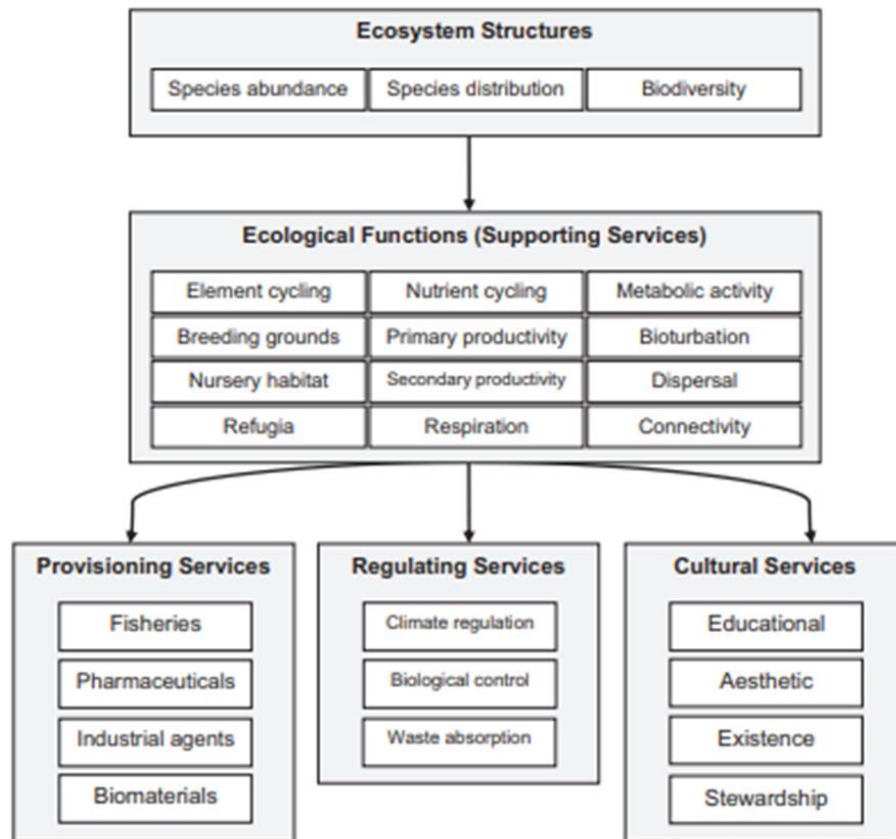
3.2 Defining Ecosystem Services

This paper will rely on the definitions provided by various scholars in this field in order to analyze whether ecosystem services are mentioned, considered, or protected in water resource governing documents. Current literature uses ecosystem services to identify functions within an ecosystem so that they can be properly monitored for conservation and protection purposes, not for monetary evaluation. The term ecosystem services will be used throughout this paper in order to relate to existing literature in this field; however, a key linguistic note should be made. Services typically implies that the ecosystem is being assessed in how it serves human societies and thus some services may be perceived as holding more value than others based on the benefits

they provide to humans. This paper reflects a precedent set by Rova and Pranovi (2017) that each ecosystem service is significant to the wellbeing of the ecosystem itself and strives to deviate from the usual anthropogenic focus human-centered on ‘services’.

While many academics in various fields of study refer to the concept of ecosystem services, often the definitions used to characterize the various services and functions of an ecosystem vary. Despite the lack of a universally agreed upon definition, the MEA is frequently cited by scholars in the field as a framework that encompasses many of the necessary aspects of ecosystem service assessment. The Millennium Ecosystem Assessment (MEA) framework, which is most widely referenced in ES literature, uses four classifications of *supporting*, *regulating*, *provisioning*, and *cultural* services (Fisher, Turner & Morling, 2009).

A study conducted by Le, Levin, and Carson (2017) provides an even more in-depth assessment on the linkages between biological ecosystem structures, ecological functions and ecosystem services that combines concepts in MEA, The Economics of Ecosystems and Economics of Biodiversity (TEEB) and Common International Classification of Ecosystem Services (CICES) frameworks — the latter two being additional frameworks inspired by the original MEA framework.



(Le, Levin & Carson, 2017)

Figure 2 provides a visual breakdown of the Le, Levin and Carson (2017) assessment that incorporates the three aforementioned frameworks. This framework clarifies that species abundance, species distribution, and overall biodiversity are the components that establish the structure of an ecosystem. The Le, Levin, and Carson (2017) framework views supporting services as ecological functions—these are ecological processes that have the potential or capacity to foster and provide ES's to an ecosystem. Some scholars go so far as to say that ecosystem processes and functions refer to biophysical relationships that exist within an ecosystem regardless of whether humans benefit from them (Costanza *et al.*, 2009). An example of a supporting service or ecological function would be breeding grounds — they are a function of an ecosystem that can provide provisioning, regulating, or cultural ecosystem services. Rova, Pranovi, and Müller observed that ecosystem service literature uses a conceptual model called the “service cascade” in order to represent the links between ecological structures, and the elements of human well-being, as well as the various intermediate stages or connections that may

connect these together (2015). The cascading nature of the diagram in Fig. 2 also demonstrates that alterations or threats to ecosystem structures or functions can impact the various ES within an ecosystem.

ES are the results of ecological functions that are supported by the ecosystem structure — they are the *impact* portion of the framework. As discussed, ecosystem services are most often classified based on whether they are provisioning, regulating, or cultural services (Carpenter *et al.*, 2009). Since many of the papers and articles dedicated to ES in the Venice Lagoon also focus on these three classifications, supporting services will be omitted as a classification in order to reflect the discourse in recent literature.

‘Provisioning services’ refers to services that combined with built devices and social capital to produce items (Costanza *et al.*, 2017). They can be considered as the outputs and products that can be directly obtained from an ecosystem such as food and timber (Le, Levin, & Carson, 2017). Built devices and social capital can be used to attain provisioning services such as potable drinking water and pharmaceuticals. An example of the interconnectivity of provision services is the following: “fish delivered to people as food require fishing boats (built capital), fisher-folk (human capital), and fishing communities (social capital)” (Costanza *et al.*, 2017). In this example, fish found in an ecosystem is the provisioning service as a food; however, it also provides *provisioning benefits* such as built capital, human capital, and social capital (Costanza *et al.*, 2017).

Regulating services act to sustain the relevant ecosystem and can be observed in examples such as flood control, storm protection, water purification, or climate regulation (Costanza *et al.*, 2017). Regulating services can be considered as the benefits from the regulation of natural environmental processes (Le, Levin, & Carson, 2017). This can include processes such as biological regulation— the biological control of pests and populations within an ecosystem (Le, Levin, & Carson, 2017). Regulating services are often overlooked by individuals as their functions and benefits are not as obvious to the average person (Costanza *et al.*, 2017).

Cultural and educational services are non-material benefits that can be obtained from an ecosystem. These services can provide aesthetic benefits such as inspiration for art or recreational benefits (Costanza *et al.*, 2017). Additionally, even the existence of the ecosystem can be considered a cultural or educational service — certain non-use-based values from various

cultures require people to appreciate the presence and nature of the ecosystem (Costanza *et al.*, 2017). It should be noted that some scholars feel cultural services should not be a classification considered in ES discourse. Boyd and Banzhaf (2007) state that ecosystem services and ecosystem benefits vastly differ from each other and should not be misconstrued. Boyd and Banzhaf claim that many of the items listed in cultural services are ecosystem benefits comprised by various services—risking that these inputs could be “double counted” (Fisher & Turner, 2008). In resource management practices, when advocating for the protection and conservation of an ecosystem, repeating or double counting these services could further emphasize the significance of these services within a system (Fisher & Turner, 2008). Therefore, it is understandable that systems that hold extensive historic and cultural significance, such as the Venice Lagoon, can potentially receive major conservation and preservation benefits if cultural services are identified and valued within the system.

Ecosystem service mapping refers to extensive data collection in the region that can identify the various services present in the region under study. Mapping tools can examine the spatial distribution of services, as well as acknowledge synergies and tradeoffs between services, compare supply and demand in order to ultimately provide comprehensive assessment areas for conservation and prioritize them (Le, Levin, and Carson, 2017). Mapping tools are able to identify ecosystem service “hot spots” — in other words, areas within a region or ecosystem that are particularly dense with services. Ecosystem mapping has consistently been demonstrated to be one of the most challenging and time-consuming aspects of this kind of approach and has been identified as one of the main elements in this work that requires the most improvement (Rova, Pranovi, & Müller, 2015). However, this process is a critical step in the application of this framework, as it transforms a theoretical framework into one that can be applied to reflect the various attributes and needs of a specific ecosystem.

3.3 Ecosystem Services and the Venice Lagoon

Lagoons are complex social-ecological systems that occur along 13% of the coastlines of all continents (Newton *et al.*, 2018). The conservation of coastal lagoons is not only relevant for their considerable ecological significance; generally speaking, coastal lagoons provide some of the following main services: food provisioning (fish and shellfish), freshwater storage, climate regulation, recreation, and ecotourism (Newton *et al.*, 2018). Therefore, the conservation of these spaces is also pertinent to the conservation of the societal, aesthetic, and heritage values that

humans may derive from residing in these areas (Newton *et al.*, 2018). The complexity of the Venice Lagoon is undeniable: there are many features that explain and provide ecological conflict (e.g., the constant fight back-and-forth between sediment and water inputs) throughout the system. Each of these must be acknowledged and considered when attempting to understand the nature of the lagoon, and how to protect it. Research in applying ecosystem services specifically to coastal lagoons is rapidly increasing, largely due to the necessity of developing a resource management framework that can respect the multiple socio-ecological components that characterize these ecosystems.

Thus far, this paper has focused largely on the geographic and ecological characteristics of the Venice Lagoon. However, it is exceptionally important to acknowledge that there are various economic activities that occur within the lagoon daily that can act as drivers of both sustainable and unsustainable changes (Rova, Pranovi, Müller, 2015). Integrating ecosystem services in ecosystem assessments and management approaches can create a clear framework that can analyze human and environmental systems, by focusing on the various linkages between natural and human systems (Rova, Pranovi, Müller, 2015). In response to this, academics within the Veneto region have conducted many studies have been conducted specifically identifying and analyzing ecosystem services in the Venice lagoon (Rova & Pranovi, 2017).

Scholars such as Rova and Pranovi (2015, 2017, 2019) have conducted extensive research on the ecosystem services of the Venice Lagoon. In the first study of its kind in the Venice Lagoon, Rova, Pranovi, and Müller (2015) conducted a qualitative mapping of the spatial distribution of pertinent ecosystem services within the lagoon. This work successfully chronicled the various ecosystem services found within the lagoon and located which ecological zones they reside in. Following this study, an additional study was publishing demonstrating how concepts in ecosystem services could be used in the implementation of the European Union Water Framework Directive (WFD) (Rova, Müller, Meire, & Pranovi, 2019). The latter paper used spatial patterns of located ecosystem services in order to indicate present, and potentially future, sustainability of these services in relation to management strategies within the area as well as the looming threat that climate change poses on the region (Rova, Müller, Meire, & Pranovi, 2019).

It is from these articles that information will be drawn in order to provide an overview on the ecosystem services offered by the Venice Lagoon and where they can be located. The study use the 11 different water bodies defined by the “Hydrographic district of Oriental Alps” to

define boundaries for identifying areas of identified ecosystem services. Therefore, if a service was mapped and identified as residing in ENC1 or the Center-Sud body of water, this directly correlates to the map of the lagoon provided by the WFD. A set of 13 ecosystem services have been mapped in the Venice Lagoon using biophysical indicators and studies conducted by ES and selected based on Rova et al. (2015) and Rova and Pranovi (2017) (Rova, Müller, Meire, & Pranovi, 2019). In a 2019 study the 13 ecosystem services identified were:

Regulating services:

- climate regulation
- waste treatment
- erosion prevention 1 (indicated by areas in which salt marshes provide a sheltering effect with respect to wind driven erosion)
- erosion prevention 2 (indicated by the sum of habitat biostabilization capacity, that reduces the bottom's susceptibility to erosion), and
- lifecycle maintenance (indicated by the sum of habitat's nursery role)

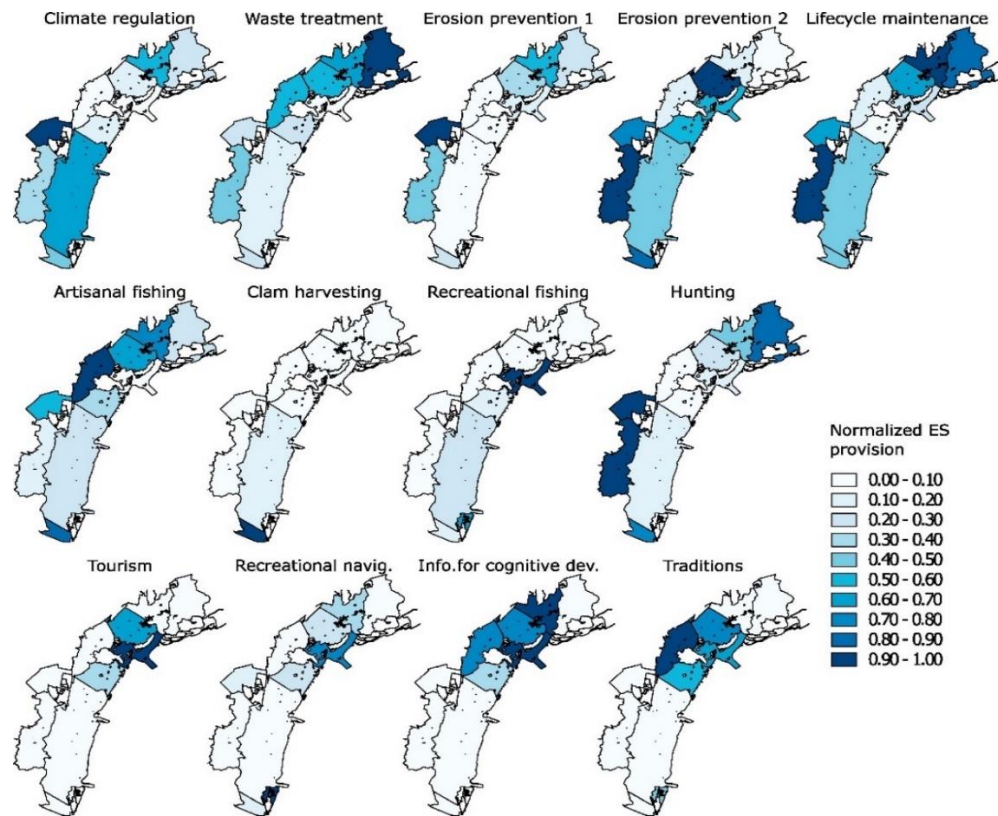
Provisioning services:

- artisanal and recreational fishing
- hunting (indicated by the yield from recreational bird hunting), and
- clam harvesting (indicated by the yield of mechanical clam harvesting)

Cultural services:

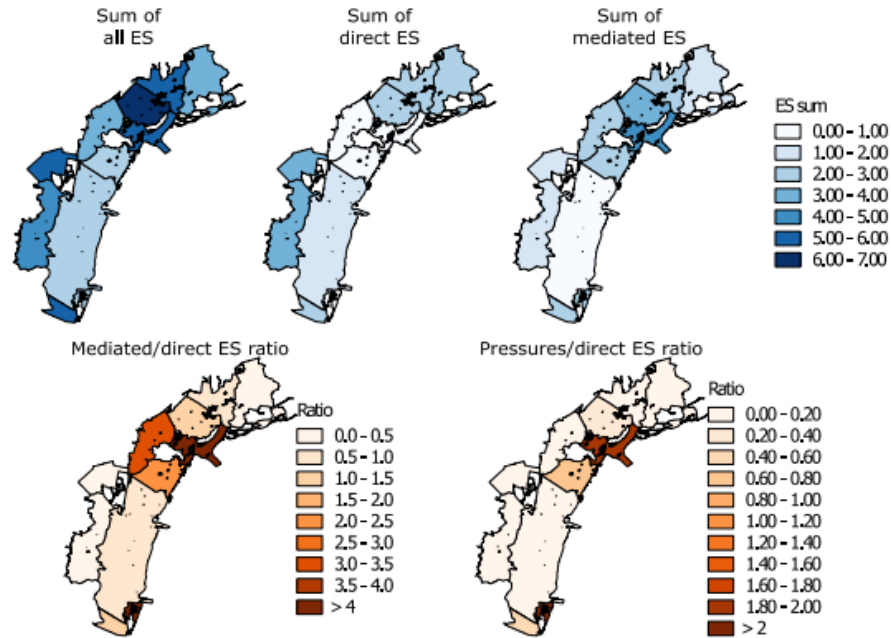
- information for cognitive development (indicated by the number of visitors through environmental education activities)
- traditions (indicated by the number of people practicing traditional activities)
- tourism, and
- navigation (indicated by the number of recreational boat passages) (Rova, Müller, Meire, & Pranovi, 2019).

The image below demonstrates the spatial distribution of each ecosystem service that has been mapped within the Venice Lagoon. There are three rows of Ecosystem Service maps each row reflects regulating, provisioning, and cultural services top to bottom respectively. The level of ecosystem services found in each body of water is normalized on a 0-1 scale (Rova, Müller, Meire, & Pranovi, 2019).



(Rova, Müller, Meire, & Pranovi, 2019).

The image above is a beautiful example of the information that can be extracted from ecosystem hotspot mapping. Of the regulating services, climate regulation is highest in confined water bodies, where a majority of the salt marshes are located, as well as approximately 90% of seagrass beds (Rova, Müller, Meire, & Pranovi, 2019). The map demonstrates trends in waste treatment, erosion prevention 2 (biostabilization) and lifecycle maintenance ecosystem services, noting that these services generally increase with the degree of confinement. Provisioning ecosystem services noticeably varied in their spatial arrangements. Artisanal fishing areas are distributed widely across the lagoon whereas clam harvesting is concentrated to the central and southern parts of the ecosystem. And finally, cultural services were noticed to share similar spatial distributions, with the majority of these located in the surroundings of the center of Venice (Rova, Müller, Meire, & Pranovi, 2019).



(Rova, Müller, Meire, & Pranovi, 2019).

The image above demonstrates the spatial distribution of aggregated indicators, in other words the distribution of all services, direct, and mediated services. Some services are considered *mediated* as the presence of additional human activities (e.g., fishing and tourism) can be in direct conflict with the sustainable use of resources, which can in turn impact the provision of other ecosystem services (Rova, Müller, Meire, & Pranovi, 2019). As can be noted above, the highest abundance of ecosystem services are located in the northern part of the lagoon in confined water bodies (Rova, Müller, Meire, & Pranovi, 2019). Confined areas of the lagoon in general seem to provide higher levels of direct ecosystem services, whereas mediated services are more abundant surrounding the center of Venice, which can be attributed to the spatial distribution of cultural services (Rova, Müller, Meire, & Pranovi, 2019). This information is extremely relevant to those looking to determine resource management courses of action. Now that critical ecosystem services have been mapped, academics, advocates, and decision makers may acquire a greater understanding of the lagoon ecosystem, and precisely identify regions of particular ecological concern. Many management documents and agencies are divided by region or authority; and therefore, such studies can reveal portions of the lagoon that may require managing documents to be reviewed and updated in order to best and more holistically represent the needs of the system.

Since the first quantitative and spatial distribution analysis was conducted on the Venice Lagoon, academics have been able to apply this knowledge to advocate for sustainable resource management within the area in various ways. For example, a 2020 study used identified ES and their indicators to estimate monetary figures for market and non-market ecosystem services (da Mosto *et al.*, 2020). The table below are the results from the study which reported the economic value (measures in monetary terms of selected ecosystems services within the lagoon).

ECOSYSTEM SERVICE	Contribution of ecosystem service (amount/year)	Current Economic Value of ES (Euros/year)	Gross Value Added (GVA) to GDP (Euros/year)	Future Value in 2050 under Sustainable Management (Euros)	Future Value under Business as Usual (Euros)
Carbon Sequestration Salt Marsh (R)	Carbon sequestration 5,700 tonnes	187,110	0	419,580	Likely to decline due to marsh degradation
Carbon Sequestration Seagrass (R)	Carbon sequestration 168,420 tonnes	5,557,860	0	13,490,385	Likely to decline due to seagrasses loss
Water Purification and Sediment Retention (R)	Annual nitrogen load entering the lagoon 6,650 tonnes	174,650,000	Most of the GVA is attributable to the ecosystem	316,354,300	Likely to decline as capacity of the lagoon to absorb nitrogen declines
Traditional Fishery & Aquaculture (P)	Mullet (valli da pesca) 500 tonnes Lagoon clams 10,274 tonnes Lagoon mussels 4.164 tonnes	18,514,000	92,570,000	44,938,330	Likely to decline as quality of lagoon degrades
Eco-Tourism and Lagoon Recreation (P/C)	No. visitors attracted to the natural features of the lagoon	Not considered therefore 0	0	An additional 1% of well conserved wetland would produce around €15m for tourism and recreation	Likely to decline alongside deterioration of environmental quality and natural capital
Cultural Tourism (C)	29 million visitor-days (presences) in historic city (2018)	Not estimated	741,000,000	Should be smaller considering generally accepted situation of over tourism	Expected to decline as quality of experience continues to deteriorate

(da Mosto, *et al.*, 2020)

Salt marsh and seagrass carbon sequestration, together with sediment retention and water purification, and artisanal fishery and aquaculture, are estimated to generate 198.9 million euros annually (da Mosto, *et al.*, 2020). Comparatively, the annual returns from the cruise ship sector estimated 376 million euro for the Venice area (da Mosto, *et al.*, 2020). While the economic returns from cruise ships may seem to be high upon immediate observation, in actuality only a small proportion of that income specifically benefits the economy of the lagoon and its historic city; meanwhile they must absorb the environmental and social costs of this industry (da Mosto, *et al.*, 2020). Should a sustainable management approach be taken to the lagoon (e.g., decreasing mass tourism to curb reliance on the cruise sector), experts have estimated that by 2050, ecosystem services such as salt marsh and seagrass carbon sequestration, together with sediment retention, water purification, artisanal fishery and aquaculture, could generate more than 375 million euros. However, should the environmental and architectural conditions of Venice continue to decline, so will the status of the city as a destination — therefore it is largely expected that revenues from the cruise ship sector will decline over time (da Mosto, *et al.*, 2020). The value of ecosystem services— if properly managed— could offset the value produced by less sustainable economic endeavour. However, this green transition relies on decision makers acknowledging the inherent value of these services and taking action to ensure their success in the future.

The transformation from a city dependent on quick returns from mass tourism to a sustainable model that may not have immediate profits, but proves to be more profitable than current trajectories in the long run, would have to be implemented carefully. The financial estimates presented in various studies, namely da Mosto's *et al.* (2020) demonstrate that a sustainable policy-making for Venice and its lagoon is not only extremely beneficial for the ecosystem, it could demonstrate higher economic returns over time, and ensure the preservation of the city's cultural capital. Studies such as those mentioned in this section demonstrate that using concepts in the field of ecosystem services allows academics to contextualize the significance of functions by demonstrating the importance of the functions in ecological terms, while also exhibiting monetary gains that would be appetizing to decision-makers, government officials, and citizens who would financially benefit from such a transition.

3.4 Ecosystem Service Assessments in Policy and Planning Decision-Making

As more research on the value of ecosystem services is conducted, it becomes increasingly clear to policy- and decision- makers that nature-based solutions can be more cost-effective than creating technical infrastructures aimed at producing the same outcome. Assessing ecosystem services within a designated ecosystem has immense potential to develop sustainable management of resources during environmental decision-making processes. Therefore, many governing bodies are beginning to integrate ecosystem services into their planning and governance mechanisms (Maes et al, 2012). Often, Ecosystem Service Assessments (ESA) are conducted in order to assess the environmental and social impacts of proposed projects in order to provide a more robust assessment than the traditional Impact Assessment that has been adopted by ministries worldwide (Rosa & Sánchez, 2016). Impact Assessments are known to be deficient in assessing the integration or importance of knowledge giving areas in the assessed environment, as well as lacking the participation of affected communities. (Rosa & Sánchez, 2016). Therefore, Ecosystem Service Assessment is an important model to consider in research as well as in policy implementation. However, in 2015, Rova and Pranovi identified the fact that existing ecosystem service concepts and assessments were lacking the ability to incorporate the active involvement of humans in ecosystem services generation. This implies that existing ecosystem concepts and frameworks are incomplete— although they may indeed disclose how humans benefit from an ecosystem — since they do not include forms of capital or forces, that aside from the natural, may need to be instigated by humans in order to realize ecosystem services' benefits (Rova & Pranovi, 2017). The presence of these additional inputs further complicates ecosystem service assessments, and therefore requires inclusion.

It is undeniable that ecosystem services have, and continue to gain, increasing levels of significance within sustainability and environmental management discourse (Rova & Pranovi, 2017). However, limiting assessments to only considering how contributions of ecosystem structures and functions benefit human societies threatens to oversimplify the complex and beautiful linkages between nature and humanity. The various benefits to human well-being that derive from ecosystem services rely on the interactions between the ecological and social components of social-ecological systems (SES). Therefore, it has been proposed that SES frameworks, an adaptation on ES frameworks, can be used in environmental management practices in order to promote sustainable ecosystem management to the benefit of ecological

processes as well as the services humans may derive from these processes. In a complex SES, subcategories (resource system, resource units, users, and governance systems) are identified in order to provide deeper context to the relationships present within the SES (Ostrom, 2009). Each of the classifications are often seen as separate; however, they interact in order to produce outcomes at the SES level, affecting all components within their subsystem, as well as other subsystems present within the total environment (Ostrom, 2009).

A deeper understanding of the influence that social-ecological processes may have on ecosystem service provisions is required in order to know how to best manage these systems so that strategies designed to maintain these processes are capable of sustaining multiple levels and types of ecosystem services (Rova & Pranovi, 2017). In recent academic literature, scholars have hoped to analyze ecosystem services using SES frameworks so that they can combine the ecological with the sociological so that ecological processes can be better considered in the resource management decision making process (Rova & Pranovi, 2017). Academics have already begun applying Ecosystem Services based frameworks in the case of the Venice Lagoon, in order to improve the existing theoretical contexts of the field, and utilize the framework as a policy tool that can unite the management of the lagoon and the city of Venice within a common long-term and sustainable perspective (da Mosto, *et al.*, 2020).

Until recently ecological and social sciences developed independently and did not easily combine; however, scientific knowledge combined with assessment frameworks such as SES based frameworks, can ensure the sustainable management of environments. So far, so many of these frameworks and proposals based on them are primarily theoretical models applied to resource problems aiming to prescribe a universal solution. However, one-size-fits all frameworks applied to specific problems in order to promote particular policy solutions repeatedly fail (Ostrom, 2009). Intense reflection needs to be conducted by decision-makers, experts, and advocates for sustainability so that they can adapt and apply these frameworks specifically to the challenges the ecosystems face in order to obtain optimal success.

Chapter 4: Discussing the Environmental Management of the Venice Lagoon

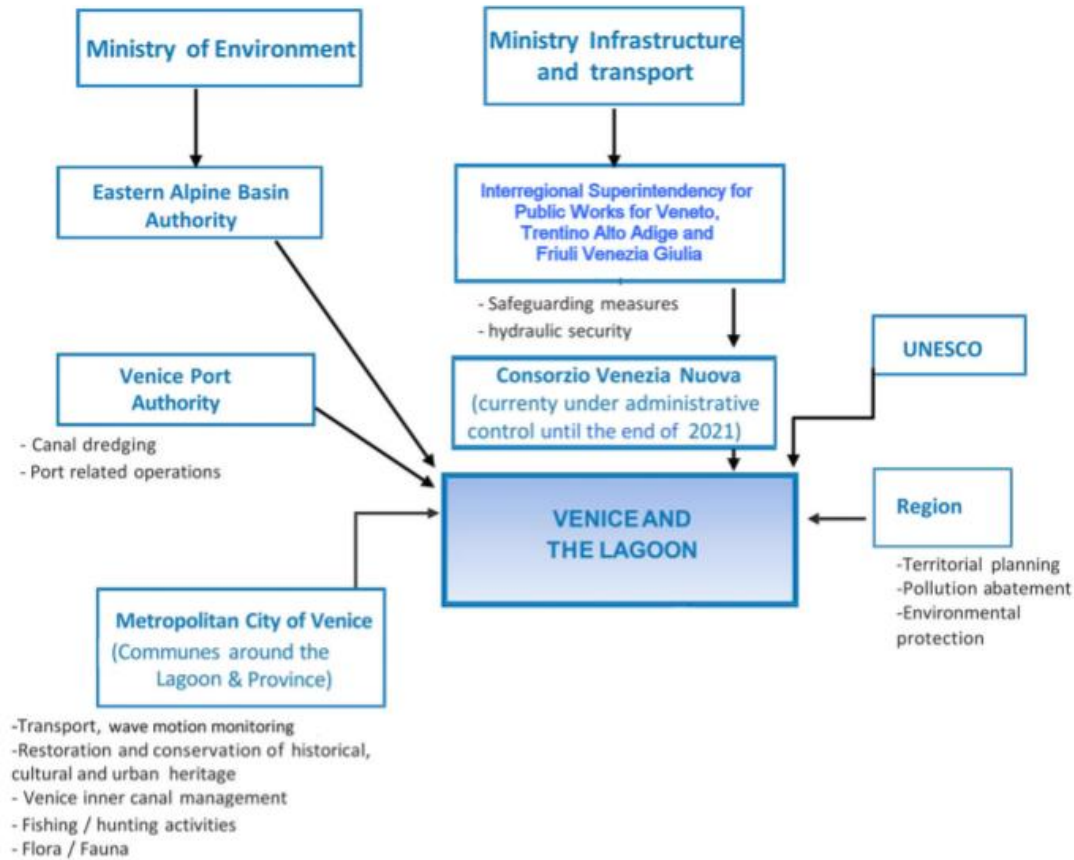
One could spend days analyzing the differences between the present and past status or use of the Venice Lagoon, but arguably, one of the most valuable observations could be discerned in management approaches that have been applied to the lagoon. Centuries ago, Venetians were not overtly concerned with ‘aesthetic’ questions regarding the lagoon — their primary concerns were with strategic security, maritime navigation, and sanitary matters (Caniato, 2005). The governing mentality was such that individual interests were always subordinated to general interests and benefits (Caniato, 2005). The Venetian forefathers were able to navigate the delicate balance between land and sea by adapting to —and by some taming— of an unstable environment constantly plagued by freshwater floods, sea-sand and river-silt deposits (Caniato, 2005). When it was in full power, the Venetian Republic implemented wide-ranging, innovative environmental management strategies in order to compete with other coastal management issues that occurred between the 14th and 15th Centuries (Suman, Guerzoni, & Molinaroli, 2005). Some scholars such as Caniato (2005, p.9) have stated that the end of the Venetian Republic can be cited as the “end of this ancient and well-balanced interconnection between Venice and its liquid surroundings”.

4.1 The Institutions that Manage the System

Shifting to modern day management of the lagoon, challenges in balancing the complicated and layered characteristics of the ecosystem have increased with each added threat or demand added to the system. One of the primary management issues that the lagoon faces lies in the fact that the competences of agencies over environmental matters are distributed widely (from the national to the local level) covering a variety of foci. Fisheries need to be preserved, migratory birds must be monitored, habitats need to be conserved, and each of these tasks are assigned to national ministries or agencies, local municipalities, or to some intermediate bodies on a regional level. Deciding which level to entrust each activity to affects the agency or authority’s territorial jurisdiction, as well as the scale of activities that the competence of the selected authority or agency should oversee (Roggero & Fritsch, 2010). Various scholars have noted the “problem of fit” in which political-administrative jurisdictions often grew in response to historic events reflecting the political or cultural divisions that may have occurred; however, often these political or cultural divisions do not coincide with the physical or ecological reality. Adler (2005), states that this incongruity can often be found in environmental politics, which in

turn leads to serious implementation deficits and decreased effectiveness in environmental protection measures. Such instances require administrative reforms that aim to improve the relationship between regulatory and ecological scales (Roggero & Fritsch, 2010). However, often improving these dynamics encounters challenges when trying to navigate how to operate at an ecosystem level (Roggero & Fritsch, 2010). An example of a possible reform could be noted in the European Union's Water Framework Directive (WFD) in which Member States were required to manage their activities on a river basin level—to do so, states had to establish basin districts as central administrative units for the oversight of the river basin. By doing so, in theory water governance would match the physical scale of the watershed resource that aims to be managed (Roggero & Fritsch, 2010)—but it adds another frame to an already complicated region.

The Venice Lagoon ecosystem faces multiple immediate and critical resource management challenges, from the actual implementation of the WFD (which would first require appropriate ecological status in all identified water bodies), to the protection of Venice from the impacts from its various threats (Rova, Müller, Meire, & Pranovi, 2019). The intricacies of the historic city and its lagoon are also reflected in the institutions and legislation that governs the region. Resolving all of these threats cannot be accomplished via one Special Law or one governing body. These struggles are experienced by various components of the overarching lagoon ecosystem and by various sectors that hope to govern the region. There are four levels of governance institutions that directly operate to administer the whole Venice Lagoon system, which encompasses the basin around the lagoon, the lagoon, the city of Venice, and the small towns surrounding the lagoon (Suman, Guerzoni, & Molinaroli, 2005). The four levels refer to: the State, the Veneto Region, the Province of Venice, and the Municipality of Venice (which constitutes the urban areas of Venice, Mestre, and Marghera) (Suman, Guerzoni, & Molinaroli, 2005). And finally, a fifth influential institution can be found in UNESCO (Molinaroli, Guerzoni, Suman, 2019).



(Molinaroli, Guerzoni, Suman, 2019).

The image above provides a visual break down of the institutional setting that governs Venice, as well as any existing relationships between institutions and agencies (Molinaroli, Guerzoni, Suman, 2019).

4.1.1 The State

The State operates through the Ministry of Public Works and the Venice Water Authority which in Italian is the Magistrato alle Acque (MAV). The MAV is responsible for the administration of lagoon areas and the coastline primarily by managing water quality and discharge permits—although today the MAV is largely known for defending the lagoon from the impacts of the sea. Special Law 780 of 1984 states that the MAV determined that the task of protecting the lagoon’s morphology and defence from high water events would be the responsibility of the “Consorzio Venezia Nuova” (CVN). Additionally, ministries such as the Ministry of Infrastructure and Transport as well as the Ministry of Environment have overarching authority of the maintenance of the lagoon (Suman, Guerzoni, & Molinaroli, 2005).

National legislation has played a critical role in the governmental oversight and funding of institutional mechanisms dedicated to the management of the Venice Lagoon — a collection of Special Laws adopted over the last 40 years which have been integral to this effort (Suman, Guerzoni, & Molinaroli, 2005). The *First Special Law for the Protection of Venice* (Law No. 171 “Interventions for the Safeguarding of Venice”) was established in 1973, stating that the environmental, scenic, historic, and socio-economic features of the region made it a substantial region of national interest (Suman, Guerzoni, & Molinaroli, 2005). This influential law paved the path for modern day resource management of the Venice Lagoon. The Special Law chartered the broad authorities of the State within the Venice Lagoon, putting them in charge of: regulating water levels in the lagoon, lagoon boundaries, port infrastructure, littoral defence, restoration of state-owned historic buildings, canal and bridge systems, restoration of publicly owned art, and management of natural and artificial waterbodies (Suman, Guerzoni, & Molinaroli, 2005). In order to protect the national assets located in the region, the Law created an inter-institutional Committee in order to maintain the responsibilities the Law imposed on the state — the Committee included: the Minister of Public Works (chair), Minister of Education, Minister of the Economy, Minister of the Merchant Marine, Minister of Health, Minister of Agriculture and Forestry, President of the Veneto Regional Commission, President of Venice Provincial Administration, the Mayors of Venice and Chioggia, as well as representatives of two additional municipalities (Suman, Guerzoni, & Molinaroli, 2005).

4.1.2 The Veneto Region and its Provinces

The Veneto Region was instructed by Special law No. 171 to develop a Regional Land Plan with interested Provinces and Municipalities of Venice, a plan that aimed to define general guidelines for development throughout the region and its provinces. Items governed by the regional plan include: establishing environmental quality limits, developing port infrastructure and delimiting protected sites (Suman, Guerzoni, & Molinaroli, 2005). Additionally, the Veneto Region and the Venice Water Authority were instructed to protect the territory from water pollution and maintain wastewaters within the watershed (Suman, Guerzoni, & Molinaroli, 2005). Law No. 171 also instituted the Commission for Safeguarding Venice (CSV) which was tasked with the mission of reviewing interventions related to buildings, monuments, and land use modifications from public or private works (Suman, Guerzoni, & Molinaroli, 2005).

4.1.3 The Municipality of Venice

The Municipality of Venice is assumed to be the most capable of managing the socio-economic development and maintenance of the buildings and local infrastructure within and surrounding the lagoon (Suman, Guerzoni, & Molinaroli, 2005). Many efforts have been made to instigate environmental coordination between the Region, Province, and Municipalities — such as Regional Law No. 32. Law No.32 established the Regional Agency for Environmental Prevention and Protection (“Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto” – ARPAV) (Suman, Guerzoni, & Molinaroli, 2005). The ARPAV is primarily responsible for environmental monitoring and outreach aimed at supporting initiatives from all three levels of government. The provinces implement enforcement and regulatory permitting activities throughout the region while the municipalities provide environmental services and maintain local infrastructure (Suman, Guerzoni, & Molinaroli, 2005).

Several institutions thus possess the administrative and technical competence to address problems related to the Venice Lagoon. Ideally, institutional coordination between the four levels of governance should support effective management of the Venice Lagoon in light of various threats that the region faces. However, political differences between the Municipality and the Region and an unbalanced (topheavy) bureaucratic structure often serves to complicate management throughout the area (Suman, Guerzoni, & Molinaroli, 2005). Regional–Provincial–Municipal planning and environmental management must not only face socio-political-economic differences between each authority, they must also confront State interest and intervention in the Venice Lagoon (Suman, Guerzoni, & Molinaroli, 2005). Scholars have noted that repeated interventions of management by State ministries acting in isolation from other levels of governance have consistently impeded regional planning efforts.

Such a complex overreaching management system poses an additional threat to the well-being of the region and the ecosystems that lie within it: gaps in management. While the National Law No. 183 (1989) instituted the Watershed Authorities of rivers, lagoons, and coastal areas (such as The Northern Adriatic Watershed Authority) no Watershed Authority exists for the Venice Lagoon (Suman, Guerzoni, & Molinaroli, 2005). Vital systems such as the Venice Lagoon and its watershed are not linked by means of a comprehensive plan, and therefore are at risk of severe and detrimental managerial oversight (Suman, Guerzoni, & Molinaroli, 2005). What this demonstrates is that while there are various agencies, authorities, and governing

documents that aim to preserve and manage the region, there is still an overwhelming threat from mismanagement and neglect within the region.

Many have stated that the complex and precarious situation of management within the Venice Lagoon demands an ecosystem-based management strategy as well as inter-governmental coordination mechanisms in order to ensure that a comprehensive management approach is instilled in the Region (Suman, Guerzoni, & Molinaroli, 2005). Suman *et al.* (2005), Munaretto and Huitema (2012) have studied the constant changes and threats present within the Venice Lagoon and the management challenges that these pose on management within the region. It was concluded by these scholars that in general, public participation or area-based management practices are often neglected by the administrative bodies when coastal projects such as public works are planned or proposed within the region, therefore leaving habitats and species within the system at risk for adverse impacts from these poor management practices. Additionally, Munaretto and Huitema (2012) assessed that multiple articles within the aforementioned special laws inhibit policy changes aimed at addressing problems on a bio-regional scale (Molinaroli, Guerzoni, Suman, 2019).

At the international level, lack of effective integrated resource management in coastal areas, nearshore waters, and watersheds and particularly the lack of appropriate national legislation, have been identified as principal factors responsible for the worldwide degradation of these environments (Suman, Guerzoni, & Molinaroli, 2005). As academics, decision-makers and advocates for the region discuss the protection of the Venice, its lagoon, and the future of region, often the “adoption of an integrated vision and of a cross-sectoral participatory approach” is discussed (Suman, Guerzoni, & Molinaroli, 2005). However, it often is the case that these suggested management approaches focus on responding to major or institutional problems, whilst oversimplifying complexities within these issues, and without recommending appropriate tools for resolution—they essentially propose applying more regulations or agencies without ecosystem or solution driven approaches to management (Suman, Guerzoni, & Molinaroli, 2005). In a system as complex as the Venice Lagoon, such approaches are not advisable . (Suman, Guerzoni, & Molinaroli, 2005).

One might wonder then, how can the environmental management of the region move forward? Perhaps the best advice would suggest adjusting existing frameworks or governing

documents to embrace ecosystem-based management strategies that focus on incorporating the nature of the ecosystem they hope to govern. The next section of this paper hopes to identify opportunities in which this improved approach to management could be implemented in existing documents.

4.2 Policy Review

4.2.1 *Explaining the Process*

A 2010 (Roggero & Fritsch) study aimed at addressing the challenge of competences over environmental matters that are distributed across multiple agencies on various scales. The paper used the Venice Lagoon as a case study to investigate whether the scale at which a competence is assessed be considered using a ‘transaction costs economics perspective’ (Roggero & Fritsch, 2010). Essentially this analysis assessed whether (for instance) rescaling certain tasks or responsibilities in governing documents, could successfully solve some of the problems posed by existing structures, or if such an approach would increase the day-to day costs for agency operations. Essentially the study found that in the context of the Venice Lagoon, rescaling existing agencies does not appear to be a feasible solution. Reconstructing ecosystem governance along these lines is most likely not an available option for promoting sustainable resource management within the region. That is not to say that the introduction of new policies or frameworks would not aid in sustainable governance, rather that there are pre-existing gaps in the relationship between agencies and the scale of the resources that they are charged with managing— all of which desperately needs to be addressed.

Due to the observations made by Roggero and Fritsch, the policy review here does not aim to reform the structure on a grand scale or provide recommendations for new frameworks or policies that could be adopted — rather it hopes to review some of the most prominent governing documents within the region to identify opportunities for the inclusion of ecosystem services or nature-based approaches to ecosystem management. It should be noted that, according to experts that were interviewed in the following section of this paper, a comprehensive list of every governing document or framework related to the governance of the Venice Lagoon has not yet been conducted— a monumental task in itself. This identifies an additional gap in knowledge within this area. Scholars such as Roggero and Fritsch have observed that while it is known that there are gaps between agencies and the scale of the resources that they are responsible for, until a comprehensive overview of governance within the lagoon is conducted, it is impossible to truly

know how large gaps in management may be. Additionally, until a review of each document that aims to identify the responsibilities of each policy, framework, and agency is conducted, it does not seem possible that mending all existing gaps could occur, given that an in-depth analysis would be required first to truly understand and identify all the gaps.

Currently, there is a lack of research in the process of combining ecological service assessments with comprehensive reviews of governing documents within a given region. At the time of writing this paper, there is a group of researchers based out of Venice who hope to complete this task and create a such a list; however, it has not yet been published. Therefore, due to incomplete data and the scope of this Masters Research Project, only some of the most prominent and most frequently referenced governing documents will be reviewed.

The chart below analyzes various governing documents for the Venice Lagoon and assesses to what degree they incorporate ecosystem services in resource management. The main purpose of this exercise is to identify areas in which governing documents can be improved upon to better reflect the ecosystem services that have been identified and valued by other scholars. For example, carbon sequestration has been identified as a function and service within the lagoon that is not only vital to the well-being of the Venetian ecosystem, but also acts as a climate regulator. It is important to acknowledge whether carbon sequestration or any of the 13 identified services are acknowledged and therefore inherently protected by the governing documents that aim to do so. Lack of inclusion or acknowledgement of these services in documents committed to the protection, conservation and management of the Venice Lagoon, may indicate a lack of nature-based management or true understanding of the valuable services the lagoon offers. This assessment, will therefore identify opportunities for better ecosystem management.

Within this section, the term “governing documents” will be used in order to incorporate treaties, commissions, protocols, pieces of legislation, frameworks, or any agreement that addresses the management of water resources within the Venice Lagoon. The terms management and governance can be used interchangeably in this context. This was done here to ensure that as many water resource management documents could be included to ensure that analyses conducted accurately reflected the management status within each system. For the context of this chart, ecosystem services refer to the various ecological functions that ecosystem structures support (Le, Levin, & Carson, 2016). Environmental service assessments (ESA), the acts of

assessing the environmental services within a designated ecosystem, have immense potential to develop sustainable management of resources during environmental decision-making. Ideally the findings from this policy review can be used in future proposals to decision-makers when advocating for the betterment of the Venice Lagoon.

The chart below will list the name of the governing document, framework, or institution responsible for the environmental protection or governance of the Venice Lagoon; then based on the contents of the document or by using secondary literature, an assessment will be made to the degree to which the document incorporates the ecosystem services of the lagoon. The documents for this assessment were selected based on their relevance to modern day management of the Venice Lagoon, as well as their reference in appropriate academic pieces dedicated to assessing the management of the system. For example, Special Laws No. 171, No. 798, No. 139 are the main laws responsible for setting the objectives, responsibilities, instruments, measures and economic resources for maintaining environmental safeguarding activities within the region (Munaretto, Vellinga, & Tobi, 2012). These laws in particular are responsible for establishing the frameworks, commissions, and designating authority to various agencies throughout the region at multiple levels of governance.

Due to the inaccessibility to some of the original documents and relying on secondary sources, for some of the laws if it is unclear how to assess the category, then ‘unclear’ will be used in order to indicate that further inspection would be required in order to make a final assessment — notes may be included in the chart for additional clarification.

4.2.2 Review of Governing Documents in the Venice Lagoon

Governing Document	Zero Ecosystem Services (ES) Mentioned	Solely commercial ES are mentioned (e.g. sustaining fisheries)	How the document governs the system (p = portions of body of water) (e= entire body of water) (v= refers vaguely to water resources as a whole)	The document acknowledges the body of water and the multiple (ES) present within it (not solely commercial ES)	Looks at the body of water and the ES within the aquatic system and the surrounding region (e.g. wetlands and marshlands)	The document is all-encompassing: includes a full ecological acknowledgment of the water system, its sustainability, as well as educational or cultural functions.
First Special Law for the Protection of Venice (Law No. 171,1973, <i>Interventions for the Safeguarding of Venice</i>)		X	E			
Law No. 798 (29 November 1984, <i>New Interventions for the Protection of Venice</i>)			E	unclear	X	
Law No. 139 (5 February 1992, <i>Inter-institutional agreement of 8 August 1993 among Venice Municipality, Veneto Region and Venice Water Authority</i>)			P			
The European Union Water Framework Directive (2000)		X	V	X	X	N (mentioned as optional on supplementary measures)
EU Natura 2000: Birds and Habitats Directives			P	X	X	
EU Floods Directive		X	P			
Law No. 395 (1991, <i>Nature Conservation Law</i>)		X	P	unclear		
Interregional Superintendence of Public Works (former Venice Water Authority) and the Management Plan		X			X	It mentions educational opportunities for the lagoon only

North Adriatic Sea Port Authority	X		E			
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Compiled from: Special Law for Venice, Venice Project; North Adriatic Sea Port Authority, Venice Port Authority, 2017; EU Water Framework Directive, European Union; Munaretto, 2011; UNESCO World Heritage, Interregional Superintendence of Public Works; UNESCO World Heritage, Management Plan 2012-2018;

4.2.3 What Does the Review Indicate?

In 2014 the Venice Water Authority was officially eliminated, which left the Venice Lagoon exposed to a lack of managerial oversight, while also threatening the neglect of hydraulic and maritime dynamics within the region (Molinarioli, Guerzoni, Suman, 2019). The decision to dismantle this authority is not the only source of gaps in management found within governing documents and frameworks tasked with handling the wellbeing of the region. As noted in the brief policy review provided above, there are very few, three to be exact, documents that view the system in its entirety, and therefore respect the interconnectedness of the bodies of water found throughout the system. This highlights the likelihood that the complexity of the lagoon is not properly reflected in the laws and frameworks that govern it; therefore posing the risk that valuable ecosystem functions and processes may be exposed to destructive impacts continuously without proper regulation.

Additionally, many of the listed documents address cultural ecosystem services such as tourism by using language not aimed at advocating for the preservation of the service itself, but in the promise of economic gain. While functions of the ecosystem may be mentioned, existing documents do not reflect an ecosystem-based approach, as the primary intent is not the conservation of these functions for the well-being of the system, but the maintenance of economic growth projections. In fact, for the shocking majority of these documents, opportunities for sustainable management within the Venice Lagoon are nearly absent. Many of these documents directly reference projects and measures directed at combatting flood management and sea-level rise within the region; however, threats to the lagoon such as climate change are shockingly unacknowledged in these documents or frameworks. In The Water Framework Directive, the Venice Specific management plan, *Alpi Orientali District*, climate change is listed as a pressing issue facing the well being of the region; however, ‘monitoring climate parameters’ is the only designated action required by agents of this authority (Munaretto, 2011). This is one of the only documents that mentions climate change and indicates the need for the region to prepare and plan according to the threats that climate change will pose to the

lagoon. The 2012 UNESCO World Heritage Site management plan (listed as the Interregional Superintendence of Public Works Management Plan) superficially mentions sea-level rise; however, it does not acknowledge the terrible ecological impacts this could have, nor does it deal with the potential for immediate action of authorities or agencies to regulate such impacts (Molinaroli, Guerzoni, Suman, 2019). According to the Management Plan of the Veneto Region, an ecosystem-based management of the waters within and surrounding the lagoon including the watershed and the adjacent sea has been requested; however, the implementation of such a plan has yet to be constructed (Molinaroli, Guerzoni, Suman, 2019).

To further address the lack of an all-encompassing ecosystem based sustainable management framework or legislation, there is a basic contention between the frameworks and authorities drafted by the instruction of earlier Special Laws, and the demands now requested by more current EU directives that request alterations to management practices. Scholars have mentioned that the parameters previously established by the Special Laws do not encourage or provide many opportunities for policy changes or reviews. This indicates that, should the various levels of institutional governance be requested to update or improve management frameworks to promote sustainability, they may be hard pressed. As already outlined, the absence of an overarching coordinating body within the lagoon, conflicts between dominating Special Laws and new EU directives, the overwhelming lack of focus on sustainability and ecological processes in governing documents, the division of lagoon management to individual bodies of water, and the looming discussion that overall lagoon management may be transferred to the City of Venice entirely— each of these considerations apply additional pressure to resource management frameworks and documents in the region.

In 2015, UNESCO warned that Venice would be placed on UNESCO’s list of “World Heritage Sites in Danger” if Italy does not implement a ban on cruise ships in the city’s lagoon and establish a plan for sustainable tourism within the region (Molinaroli, Guerzoni, Suman, 2019). So, how does the region move forward? Numerous studies have proposed management frameworks that could be adopted by the multiple levels of institutional governance within the region, namely frameworks that incorporate concepts from Ecosystem Services (as outlined in an earlier section) in order to promote ecosystem-based approaches to management. Such approaches to resource management would consider regional ecosystem impacts from measures

implemented in and by the region, as well as the contributions to society and ecological well-being that the ecosystems themselves may offer (Molinaroli, Guerzoni, Suman, 2019). A key observation this paper wishes to highlight is that for any of these proposals to be remotely effective, first it is critical that extensive consultation and involvement of all stakeholders in the region (policy makers, scientists, private sectors, and civil society) be conducted in order to identify a common goal regarding the future of the Venice Lagoon. Such a consensus could trigger a major reform in management approaches applied to the lagoon.

Taking this conclusion seriously sparked the transition of the research for this paper from a policy review to a collection of personal interviews with stakeholders in the region. Policy reviews are effective at identifying gaps in management or opportunities for sustainable reformations. However, without a solid understanding of the wishes and needs of the general public and those invested in the region, various agencies, academics, and advocates may disperse energy— addressing different goals further dividing resource management endeavors.

Chapter 5: Stakeholder Interviews

5.1 Purpose

In order to gain a complete understanding of the Venice lagoon, I attempted to familiarize myself with the geographical and ecological structure of the lagoon, the biological and anthropogenic impacts that threaten its wellbeing, the various management frameworks that govern the system, and try to locate key ecosystem services in order to identify opportunities for improved management of the system. However, much of this work— notably ecosystem service assessments and theories in sustainable resource management— relies on theoretical frameworks and therefore there is a risk that these concepts may be glorified in theoretical projects as solution to management issues, but they may not be practical or possible in application. To truly provide a comprehensive analysis on the Venice Lagoon, this project decided to interview community members and stakeholders that depend on the Venice Lagoon in hopes that these interviews would provide insight to the ecosystems services that hold the most value to them, catalog the threats they are most concerned about, and with luck bring to light any ideas for solutions or next steps.

I conducted interviews with community members and stakeholders that depend on the Venice Lagoon. I wanted to ask whether they feel that the services they mention are properly protected from threats of environmental degradation. This will ultimately serve as the final component to my research question: whether management frameworks governing the Venice Lagoon respect the needs and values of community members and stakeholders in the region?

5.2 Methodology and Participant Selection

Due to the multi-faceted and interdisciplinary nature of this research project, it was important that the selected participant pool reflects the complexity of this topic. Therefore, it was my intention to interview various stakeholders in the wellbeing of the Venice Lagoon. This included but was not limited to city and lagoon planners, harbour masters, political officials, members of environmental organizations, academics, and citizens of the region who were impacted by the Venice Lagoon. Organizations, academic, and research institutions within the region were researched in order to identify experts that may contribute insight to the wellbeing of the lagoon. Research on former and current political officials or decision makers was conducted to identify potential participants from that pool of expertise.

Ideally informed citizens of the lagoon, decision makers, members of non-profit organizations, and academics were to be interviewed in order to assemble a robust and diverse collection of observations. Unfortunately, Covid-19 largely inhibited the ability of this study to reach a diverse audience. Initially, I intended to travel to Venice in order to connect with communities throughout the region in order to meet participants. Due to travel restrictions, as well as the hazardous risk of in-person contact, this was not permitted. An additional complication involved reaching out to politicians or decision makers, since often interview request emails were left unanswered. However, among the most responsive groups of participants were academic experts and non-profit organizations. Individuals from these participant groups were not only enthusiastic about participating but were also able to provide networking opportunities for others who might be able provide additional input. Therefore, while the interview participant pool is not reflective of all the thoughts, opinions, or feelings of the region, it does provide further context for some of those most in tune with the ecological nature of the lagoon and its needs. Despite the size of the participant pool, the seven conversations were illuminating and inspired many of the recommendations listed in the final remarks of this paper. Further research could be conducted that focuses on connecting these statements to those from decision makers in order to promote a larger discussion about the needs of the lagoon and how these needs can be realized.

Each interview was approximately 40-50 minutes long and held over online meeting platforms such as Zoom, Skype, or Google Hangout in order to ensure the maximum safety for all involved, and were conducted from May until July 2021. Ideally 12-15 participants were expected to contribute to this project. More ordinarily might be expected in a thesis project; however, since this is a Masters level major research project the participant pool was kept small to ensure that the project could be completed in time within the necessary time frame of the Masters in Environmental Studies program. This paper has, up until now, sketched out the complicatedness of the lagoon; however, trying to secure a diverse collection of stakeholders to participate in this study rivalled the complexity of the natural ecosystem.

In the end seven participants from a diverse range of fields participated. All apart from one participant were residents of the Venice Lagoon or its watershed. Academic experts referenced in this paper — Rova, Pranovi, and Onofri — were interviewed because they were

large contributors to the background of this study and provided greater context to the implications of their research. We Are Here Venice (WahV) is a prominent non-profit association that focuses on addressing the various threats to Venice and advocates for evidence-led policy decisions—I was fortunate enough to interview the founder, Jane da Mosto and WahV’s Chief of Science Camilla Bertolini. Additionally, researchers from University of Padua’s Rethinking Climate Change: The Venice Paradigm program were consulted. And finally, Professor of Urbanization from Iuav University of Venice, Maria Chiara Tosi participated.

5.3 Interview Questions

The questions asked focused on discussing the participant’s relationship to the lagoon, their opinion on whether the ecological integrity of the lagoon is properly protected from threats of environmental degradation, and their opinion or ideas on how to improve the environmental protection and conservation of the lagoon in the future. Interviews occurred from June 1st-July 19th 2021. The appendix contains the list of questions that participants were asked. It is important to note that each interview was unique: some participants answered the later questions earlier on in the interview; so, in order to avoid repetition some questions were not asked. Finally, the wording for these questions was changed frequently in order to maintain a natural or conversational aspect to the interviews. It was found that the more informal or unstructured the interview became, the more professionals divulged further information regarding their academic and personal experiences with the Venice Lagoon.

5.4 Interview Responses and Reflections Gained

Rather than transcribe each interview directly into this paper, responses were summarized and compiled in the following subheadings. Many of the ideas shared in the following paragraphs were repeated or echoed by multiple (if not by all) participants, therefore direct quotes are not often presented. This process is based on the thematic coding approach researchers use to sort through and analyze qualitative data, such as interviews (Gibbs, 2007). This approach requires the researcher to retrieve all of the relevant text (in this case interview transcriptions) and combine samples that share similar ideas or explanations (Gibbs, 2007). This is an effective way to organize large quantities of qualitative data. Should dissenting opinions on a topic occur, the context of the speaker will be given whilst maintaining their confidentiality.

Each heading represents either one particular question as is listed in Appendix 1, or they have been combined to reflect a broader conversation that was shared by multiple participants.

5.4.1 Connecting lagoon and individual health and well-being

Every participant agreed that the health and wellbeing of the lagoon is both directly and indirectly related to their own personal health and well being. One participant beautifully stated that “my health and wellbeing is not separate from the health and well being of non human life, I believe in the interconnectedness of everything”. Participants that live in the city of Venice, or in residential areas around the lagoon, remarked that their lives and the environment are inherently connected; however, in recent decades, they believed that viewing the city and the lagoon as a co-evolving unit has been lost on decision makers and environmental managers. As the morphology of the lagoon has changed, the communities that conduct activities within the region have also have had to adapt.

When cruise ship wakes or emissions devastate the environment, these effects can be felt throughout the region, for example by contributing to the erosion that disrupts salt marshes, or aquaculture breeding grounds that therefore impacted accessibility to provisioning services. The conditions of the lagoon certainly have an effect on humans, given that certain changes to the morphological structure of the lagoon make the city more vulnerable to flooding, an ongoing concern experienced in the region. Whether it is one’s own basement flooding, or cultural important monuments suffering such devastation— these and other problems can also impact residents of the lagoon.

A student and researcher in Venice reminisced on the various threats present in the lagoon and how of course these threats affect human life at various scales. For example, the Venice Lagoon is a carbon sink which collects carbon from its surrounding environment — the more that the environment deteriorates, the more we suffer as human beings. Regardless if someone resides right in the heart of the Veneto Region or in Canada, the status of the carbon sinks in the lagoon in a way influence our overall health because global atmospheric carbon would be higher. However remarkably, the interviewee stressed the effects on their mental health. The student stated that the dichotomy between two parties governing the lagoon, one in favor of protecting the lagoon and one seemingly indifferent, has contributed to an anxiety experienced by the participant. They stated that they are aware they need to protect the lagoon,

and that it is worth protecting, but the feeling that if higher powers do not change and choose protection, the system will die. That is a heavy mental load to carry. At times it can feel while watching the lagoon deteriorate that until decision makers and environmental managers come together to make an effective plan with a common goal, all advocacy or academic endeavors are fighting a losing battle.

5.4.2 Discussing the threats to the health and wellbeing of the Venice Lagoon

Naturally each participant had concerns regarding the health and wellbeing of the lagoon; additionally, they were able to elaborate on specific threats their experiences or expertise deemed to be the most pressing issue. Environmental and ecological concerns were mentioned by each participant — namely: loss of salt marshes, pollution, the cruise ship industry, over tourism, global sea level rise, and mismanagement of the area. Three participants discussed the disappearance of marsh land and seagrass meadows in the lagoon, with one stating that in the last century at least 100 km² had disappeared due to high-speed boat traffic and erosion. Two participants in particular were concerned that this issue is further exacerbated by the lack of sediment flow into the lagoon, and therefore the marshes do not have access to materials to regenerate themselves and that the relationship between the lagoon, its sediment budget, and salt marshes is a much more complex and pressing issue that needs to be better understood.

It is important to note that depending on the academic field of each participant, their personal relationship with the lagoon, or their career path, different threats were considered the most pressing. For example, environmental scientists mentioned tourism and cruise ships as a dominating concern and threat to the well being. Some stated that despite the wake and erosion impacts of cruise ships, there is also so much waste and pollution emitted from these vessels that they are a threat to the environment and to the people that rely on the environment. Additionally, academics stated that while the obvious threat may derive from the use of these ships in the lagoon, the impacts are exacerbated and determined by the region's heavy reliance on the tourism industry, an industry they fear the region will never be able to part from. A prominent local economist stated that while it is true there is a monoculture of tourism and the cruise sector the actual main economic sector for Venice is the maritime sector. Commercial shipping is the dominant economic driver in the region. The economist stated that every year this sector produces 11 billion euros compared to 0.8 billion euros generated by tourism, and yet people seem to view tourism as the industry that the region cannot survive without. This participant

stated that misinformation shared between the sectors, academics, and advocates is the real threat to the wellbeing of the lagoon because it misleads people to focus on problems and solutions that may not be the most relevant.

Often it has been the case that when a threat presents itself conflict between the environmental and societal needs arise when attempting to concoct a solution to the problem. One of the main tasks focused on by decision makers that represents this division, is the defence of the city of Venice with the Mose barrier. Despite media appraisal of this billion-euro technological innovation, each participant had severe reservations about plausibility of the barrier's success, and were extremely concerned about the adverse environmental impacts that may occur due to this approach. A professor of urbanization from the University of Venice stated that the Mose barrier was a "project devoted to the city of Venice, but it is not a project for the lagoon". They continued to state that when international newspapers covered the first time the barrier was officially used in December 2020, many praised the notion that the city of Venice was protected from high tide, but meanwhile the lagoon suffered from the reduced oxygen circulation.

These statements allude to comments made by fellow participants stating that the most pressing threat to the well-being of the lagoon is in fact the mismanagement of the entire system. Dr. Fabio Pranovi stated that the main issue facing the lagoon is that "the environmental managers have to decide which kind of a lagoon we want to have [...] there are a lot of drivers of critical elements, climate change for example [that threaten the lagoon] but in order to face these pressures, we need to decide which lagoon we want". While each participant uttered similar claims, what was shocking to learn is that this is a critical conversation that Pranovi claims environmental managers are not having. It was stated that the current mindset of decision makers and managers is the perspective that we can address and solve one problem at a time. For example, first they will face flooding, then once a solution for deterring floods is reached, then maybe the next step would be to look at the circulation of the lagoon, not realizing failure to do so at the onset of problem-solving poses detrimental risks to the entire system. And so on.

5.4.3 Utilizing Concepts from Ecosystem Services

All participants interviewed had a deep understanding of concepts in the field of ecosystem services and had each encountered papers or projects specific to the lagoon. Without

wanting to repeat content discussed earlier in the Ecosystem Service portion of this paper, time will not be spent on listing the services recognized by each participant. However, an interesting conversation did occur regarding the anthropocentric nature of the field. After discussing the services found the lagoon, it was asked whether alternative words or concepts that utilize a similar framework could better represent the relationship between ecosystem functions and those that depend on them without becoming so anthropocentric. One participant stated in essence that there are currently no other alternative mechanisms to use; however, it was noted that in ecosystem service theory there is the overarching classification of ecosystem functioning. The functions of the ecosystem are behind the service, and therefore if research or management practices ‘strip back’ to address the functions behind the services, this could ensure a more holistic approach that supplants the anthropocentric nature of ecosystem services. Two participants similarly stated that ecosystem service-based approaches to resource management allow for nature-based solution-oriented thinking, so long as those utilizing the framework do so with that goal in mind, essentially, protecting the function and ensuring the service.

5.4.4 Does the valuation of services impact the level of protection they receive?

Monetary evaluation of ecosystem services has been hypothesized by some scholars as affecting the management approaches taken to protect said services. This section aims to discuss whether monetary valuations of ecosystem services influence the level of protection they may receive. One participant immediately remarked that they do not believe authorities are adequately protecting services deemed to be significantly monetarily valuable currently, thus indicating that while monetary valuations can appeal to decision makers, they do not assure protection. There are many services that have been identified as monetarily important such as carbon sequestration. Blue carbon is a current hot topic in the region, and while carbon markets are in their infancy, they demonstrate a rare opportunity for sustainable economic development in the region; and yet not many officials acknowledge or realize the full extent of the value of carbon sequestration potentially present in the lagoon.

Prominent scholars such as Pranovi stated that we need to move far away from the idea that services need to be evaluated in monetary values. This is because monetary valuations pose the risk of underestimating the real value of ecosystem services, which would add additional stress to the system. A professor of economics from the University of Padua agreed, stating similarly that putting a value on nature can introduce the system to numerous critical issues.

Some ecological functions cannot be cashed out in terms of GDP or monetized— should that indicate that they are less important than those that can? Of course not, and yet this is a risk that could arise. In many cases, ecological dimensions are more valuable than can be measured in monetary terms; so truthfully, other than by providing some general indications of worth, these evaluations in many ways can undermine the management of an ecosystem. Pranovi declared that currently services are not valued and protected equally within the lagoon system— it is notable that touristic ecosystem services are maximized. As Rova articulated in their interview, a holistic and balanced approach in which each service is viewed as equally significant to the wellbeing of the lagoon would be optimal for promoting successful sustainable management within the region. Additionally, Pranovi reflected that if there were to be a “most significant” category of ecosystem services, it would be services that directly relate and influence ecological processes within an environment, i.e., regulating and provisioning services. However, it is important to note that their significance ought to be again determined by their service to the ecosystem and not for human usage.

5.4.5 What is being done to protect critical ecosystem services?

In this segment, participants were questioned on their knowledge of projects or legislation that might be used to ensure that the critical ecosystem services discussed earlier were protected. One participant mentioned that in all earnestness, the majority of efforts towards lagoon protection comes from NGO’s working on advocating for the ecosystem on a voluntary basis. This participant emphasized that it is through stubbornness and the desire “to protect the ecosystem that we love” that conservation projects are born, not through a framework of legislation, although they noted that that is not as effective as protection or conservation efforts imposed by legislation. There are multiple European based projects that have been dedicated to identifying various ways to protect the edges of salt marshes from erosion and to promote the recolonization of the lagoon bed with seagrasses. There is also an organization called Life Lagoon Refresh who oversees projects dedicated to reintroducing fresh water in the lagoon.

It has been noted already, that carbon sequestration was a hot topic mentioned by all participants at least once in their interviews. The organization WahV has established a new partnership with VITAL (Venice Natural Capital) in order to develop the lagoon restoration work as a carbon offset. The partnership would establish a certified opportunity for voluntary carbon markets. WahV founder da Mosto stated that this proposal can provide explicit market

value that would aid in overcoming people's difficulty in recognizing carbon sequestration as a valuable ecosystem service. In very recent and exciting news, WahV has been awarded a European new green deal project that will focus on investigating the best methods to regenerate salt marshes in the lagoon.

5.4.6 Do some areas of the lagoon require more protection than others?

Similar responses were provided by all participants that were asked this question. All participants acknowledged that the northern part of the lagoon (which loosely references the semi-confined area of the lagoon above the Lido inlet) is the region in which the largest quantity of natural marshes remains. The centre-south region of the lagoon (the large space below the city of Venice to below the Malamocco inlet) was confirmed as one of the most compromised regions of the lagoon, due to industrial activity and large vessel traffic which has destroyed the majority of biodiversity in the area. The southern part of the lagoon (loosely refers to areas surrounding and below the Chioggia inlet) is referred to as experiencing a medium level of impact from human activity—it is not devoid of all diversity, although a large portion of habitats in the area have been eradicated over time. Despite general consensus on the state of each water body or general region of the lagoon, challenges arise in deciding whether some areas require more protection than others.

A prominent dichotomy in the interviews was whether the northern or southern areas of the lagoon require increased, immediate, and intense protection as compared to other regions. Pranovi stated that the centre-south is technically considered a lost area in terms of ecological processes in that there is not really anything that can be done to improve the limited ecological processes that have managed to cling to existence in the area. In comparison, another participant listed the centre-south and southern parts of the lagoon as requiring more investment of protection because they are most fragile, with the centre at the greatest risk of becoming a branch of the sea. This fragility would require immediate and immense levels of protection in order to maintain the current morphology of the lagoon. The advocate and environmental scientist Jane da Mosto listed the northern part of the lagoon as the most important area to protect because it has the most pristine salt marsh and “we have to take care of that because it is all we have got left”. There are various interventions occurring in each of these areas aimed at regenerating the environmental integrity of these bodies of water; however, there seems to be a struggle over “what do we protect next?”. Should interventions focus on protecting the north to try and

maintain the biodiversity that has been able to survive; the south to try and maintain current levels of diversity to ensure further degradation does not occur; or focus on the centre-south to attempt to remake it as it once was?

Other participants such as those with an economics background stated that identifying areas that require the most protection depends on what services you are valuing or focusing on to protect. One could argue that since aquaculture and fishing hold significant economic value for the region, areas that hold these activities should be the focal point and management should be rearranged to reflect this focus. However, one participant went on to say that ecologists know that the functionality of the ecosystem is a complex game which depends on the functionality of the entire ecological system. Focusing on one aspect of the lagoon for protection poses its own risks as it increases the potential for complex dynamics between bodies of water within the region to go unnoticed. Pranovi echoed this sentiment stating that protection focused management strategies must encompass the entire lagoon. While there is sense in dividing the lagoon into distinct bodies of water to reflect differencing environmental conditions, it is critical that this does not lead people to think each area is an island. Each water body is connected to the lagoon and interact with each other in various ways.

The chief scientist for WahV asserted that “maybe it’s not that we need to protect one thing or region, but that we need to stop the causes of lagoon damage. Protection in the classical sense is similar to putting a patch over a hole, it doesn’t work on its own”.

5.4.6 Are there future legislation or projects dedicated to the protection of the lagoon?

Questions in this section focused on reviewing any knowledge participants might have for upcoming reformations or even the creation of new pieces of legislature, resource management frameworks, or forums dedicated to the protection of the Venice Lagoon. One participant mentioned that at the time of the interviews the Italian parliament was discussing and reviewing proposals from different political parties regarding new ways to organize the governance of the lagoon. The participant noted that one thing everyone agrees on is that how governance is done now is not functioning. They continued to list some of the proposed suggestions which included: follow current laws but place all the power into the hands of organizations and agencies within the lagoon; the complete rewrite of new laws; and finally, some prefer to keep the system fragmented as it currently is. Another participant mentioned that

an ongoing threat to the lagoon includes the privatization of several islands which would contribute to losing the publicness of the lagoon. Therefore, many Italian institutions are discussing how to define and control public goods utilizing the Venice Lagoon, particularly focusing on the fishing valley as a case study (as it currently not a public or private entity).

It would seem that there is nothing official to be expected in the coming months; however, there are some very important conversations occurring that could result in future legislation or projects dedicated to the protection of the lagoon.

5.4.7 Are current pieces of legislation or projects effective?

This section was tasked with asking participants if they felt that current legislation, resource management frameworks, or projects were adequately or effectively protecting the lagoon. From a majority of participants, the immediate answer was “I think not” and they would then proceed to identify faults in current management. One participant initially declared that if you were to assess the effectiveness of governance or management of one single area, the answer could be yes. However as soon as assessments turn to analyze the entire lagoon at an ecological perspective, the answer would be no. Currently legislation and management projects are effective at protecting a small portion of the lagoon with relatively good results; however, the lagoon is not a single environment and functionality is related to the entire unit of the lagoon — it is not possible to protect a singular small area and hope that it will have a high impact that will extend to its surroundings.

The chief scientist of WahV stated that an ecological plan was developed in 2016 and it went through various stages of review; however, it is now waiting somewhere for signatures from members of the Italian government. While there are numerous projects, laws, and management frameworks applied to Venice, many agree they do not operate optimally. Many of the latest suggestions and innovations are lost somewhere between half completed and half on hold. The fragmented structure of management in the lagoon has left institutions and agents to operate of their own accord within their designated areas. Multiple participants stated that this disconnect is largely responsible for failures in effective protection-based legislation, frameworks, and projects. The chief scientist stated that what is missing is a vision of the integration of knowledge across academic fields and governing bodies. Potentially, it was argued, given the current disconnect, project managers are not convinced of the research

academics are doing because everyone seems to focus on separate topics using field specific language that may not translate effectively; and with no one tasked with ensuring this information is shared properly, it becomes lost on other stakeholders in the lagoon. This disconnect is a major issue from the legislative point of view because government officials see that protection and conservation projects have been mandated, but the execution of these projects can be extremely ineffective due to lack of integrated collaboration.

A professor from the University of Venice mentioned that additionally, decisions regarding how existing laws may be used have changed throughout recent decades, which were having considerable impacts on the protection of the region. The academic provided the following example. In 1973 the First Special Law for Venice was formed and it established the rules for everything that occurs in the region. As a national law it brings in national funding and at its onset this funding was provided to inhabitants of the city so that they could restore their homes and prevent the abandonment of residents in Venice. In the 80s focus shifted to preserving, restoring, and protecting the city of Venice, and in response all the funds that were received at the national level began to be invested into the Mose project. With a majority of funds directed to this large project, city restorations and other lagoon focused protective measures were severely hindered. The professor stated that the inability to afford or maintain housing in Venice, has contributed to creating an “empty city” in which the people who experience life in the lagoon and care for lagoon’s wellbeing are leaving. This exemplifies the fact that if decisions regarding the uses of existing legislation are made without the integrated knowledge of various stakeholders throughout the region, what may be considered a solution to a threat could further exacerbate other vulnerabilities in the region. As of right now, the participants stated that this dynamic has been noticed by the authorities and this Special Law is being reviewed by Italian government; however, conflicting interests from the several different political parties has prevented a final decision from being made.

5.4.8 Is it possible for governing documents to protect the environmental integrity of the lagoon?

Many participants stated that yes, it is possible for governing documents to effectively maintain, protect, and advocate for the environmental well-being of the Venice Lagoon. It would require that these documents recognize the lagoon as an entity. The chief scientist of WahV stated that Venice finds itself in a lagoon, it is completely embedded in its surrounding

environment. Legislation should not focus on Venice, but respect the dynamic and ensure when the historic city Venice and the lagoon are referenced.

Another participant was not so hopeful. They stated that they do not believe one document or framework is capable of managing such a complex system as the Venice Lagoon. Instead of environmental legislation or mandates, two participants suggested that national, international bodies or civil society organizations are needed in order to hold environmental managers and decision makers accountable and monitor the system, because it is not believed that regional institutions have proven themselves capable of doing so. One participant remarked on an interview they had with the city's representative for climate change regarding the mayor joining the C40 Mayors for the Environment group in 2012. When the representative was requested to provide the most recent environmental assessment reports for the participant to use in their own research, it was noted that they had only recently started drafting reports, despite being a member of this initiative for nearly a decade. The participant emphasized that projects, initiatives, sustainability goals can all be mandated and promised, but unless there are accountability measures or authorities in place these initiatives can become ineffectual. Venice and its lagoon are a UNESCO Heritage Site, and protection of the region should reflect this level of significance.

One additional concept discussed by multiple participants is that until a consensus is reached about what type of lagoon we want in the future, existing documents will continue to encourage stakeholders to work independently of each other without a common goal. Pranovi stated,

“if we want a Disneyland or a thematic park for tourists we can decide this, its not a problem. In this case we can also produce a park around Venice [...] but then you need to decide that you don't want a natural environment around the lagoon. We need to decide which lagoon we want”.

He further stated that stakeholders need to have the conversation of what type of lagoon we want, appoint people or a commission to make the final decision. No one wants to be the person that says, we are turning Venice essentially into a theme park; but it is not sustainable for everyone to be working towards various social, environmental, economic, and political endeavors without a common understanding on what expectations for the future of the region are.

5.4.9 What is missing in conversations about the Venice Lagoon?

Participants were asked: When politicians, experts, or members of the public discuss the environmental protection of the Venice Lagoon do you feel that all aspects of the lagoon are being considered? Once again, participants mentioned the overall disconnect in communication among stakeholders within the region. There is ongoing polarization when discussing environmental protection and the future of the lagoon. Pranovi stated that it's usually impossible to have discussion between polarized groups, and theorized that this could be related to the fact that management solutions tend to focus on one problem; and if stakeholders do not view the problems the same or do not share their views on the problems, they may not be interested in investing in solutions that divert attention away from their own challenges. Pranovi stated that often decision makers want to solve an issue, but rarely do they assess the entire picture. Another participant acknowledged that even when attempting to address a problem in the region, "everyone is looking at their own aquarium". The systems currently set in place do not promote the sharing of information or resources. The participant noted that in fact even within some of the same economic organizations individuals have differing data for the same phenomenon within their own economic sector. This is because different methodologies can be used to gather data. A professor from the University of Padua said that we need to integrate thinking across fields and sectors so that homogenized data collection and analysis can occur, and that we can truly know the realities of the lagoon, otherwise the problems will continue to come up one after another. Pranovi then noted that even when resolutions are drafted, they first address social based problems, followed by economic problems, and only once the first two are addressed does attention turn to environmental issues.

A research student in the region stated that "everything is being left out" and provided the example of a motion passed early in July to redirect shipping traffic in the lagoon. They said that large vessels such as cruise ships are still entering the Venice Lagoon, but they will no longer be passing through the centre canal. Tourists and those on the main island will be able to avoid the eyesore of these vessels; however, they will still be present, polluting and disrupting the lagoon, despite media outlets praising the removal of ships from the Venice Lagoon. One mentioned that there are lots of conversations regarding environmental protection occurring, but their scope is too small — either they want to protect a small thing or conversations are not followed through. The participant reflected that these conversations regarding the lagoon lack a forward vision,

people are stuck trying to return the lagoon to what it once was, but that will be nearly impossible. They said that we should discuss a future version of the lagoon and use that vision to motivate management efforts moving forward. We need to know what we are working towards in order to establish legislation, frameworks, and projects that work towards a common and defined goal.

5.4.10 Potential solutions to threats facing the Venice Lagoon, and the obstacles they may face

All participants had an air of hopefulness when discussing potential solutions for addressing the threats that face the Venice Lagoon. While many remarked that there is not a one size fits all solution that can address all issues and challenges within the lagoon, there are approaches and opportunities for us to move forward.

The chief scientist of WahV stated that utilizing nature-based solutions and approaching lagoon management with a holistic mindset in general is the attitude that will lead academics, advocates, and environmental managers to integrated solutions. They stated that “the main solution is remembering to put the lagoon as a priority; if you put it as a priority, solutions will cascade from it”. When you put people into the context of a nature-based framework, nature and local people are addressed and valued simultaneously. Framing the problem of Venice and the lagoon may be the very first step and challenge to overcome, but once the right framework is applied, solutions can potentially create themselves (e.g. using local fisheries and fisherpeople to seed oysters that are capable of blocking erosion, thereby creating jobs and environmental defense). An example of a wonderful nature-based solution that is supported by the EU and run by the University of Padua was mentioned by a professor of urbanization from the university. The project proposes that fisheries plant a specific kind of vegetation that has the capacity to reinforce the border of the marshland. This could potentially restore and regenerate the marshland. The project would be carried out by local people, such as fishermen, who have the specific knowledge of where this vegetation should be planted. The project has been recognized and received funding from the Veneto authority due to its strong potential to restore marshland.

Dr. Silvia Rova stated that the ecosystem services approach could be the very approach or management strategy capable of providing such a framework. Rova stated that ecosystem service frameworks could act as a translator for managers of what is occurring in the lagoon on ecological terms and of course how human interactions or modifications may influence these

dynamics. Ecosystem services could even be used as a tool to create models or simulations of “what if” scenarios. Ecosystem service mapping provides an in depth understanding of the services and their interactions within a system. These can then be tested against proposed solutions in a simulation, something that could have been used to initiate earlier discussions about the impacts the Mose barrier may have on the Venice Lagoon.

From an economic perspective, things are complicated. There are many trade-offs that must be considered when evolving industries to adopt either more sustainable practices or adapt to a changing lagoon. There are many different economic activities within Venice, many of which directly impact the environment. Sometimes solutions that have been proposed by various institutions to address an initial problem, and then subsequently create more. A professor of economics at the University of Padua provided the following example. The maritime industry is a dominant economic sector with major environmental impacts. If safeguarding the lagoon becomes the priority, it then follows that one should move all big ships outside of the lagoon to dock at an offshore platform. However, in lagoon adjacent areas the locations best suited for hosting such a platform are highly productive fishing and aquaculture areas— thus initiating interrelated friction between industries in the region. The numerous conflicting interests in the region paralyze all efforts to move forward.

We can adopt nature-based solution approaches to management, and create simulations and models, but actually making the tough calls when assessing trade-offs from these proposals is one of the last mountains to climb before these changes can be made. In addition, it was noted that when assessing the impacts of solutions experts need to plan or understand the entirety of the situation; however, information regarding the area is so poorly collected that there have been instances in which managers within the same institution have different statistics and data. There is a drastic need to integrate the various institutions and stakeholders that operate in the area so that information can either be properly integrated, or be made public.

Policy changes, management approaches, and ecosystem-based frameworks can be proposed. However, WahV founder Jane da Mosto beautifully articulated that “we need to fix a desired optimal state for Venice in order for it to be in the future”. Dr. Pranovi echoed this sentiment stating that “we need to decide which lagoon we want”. Da Mosto alluded to the notion that the solution lies in this very discussion. Venice is becoming a bay of the sea. As a

whole we must decide if we will let that continue to happen, in which case the solution is: we tell everyone Venice is the next Atlantis and allow activities to continue in this expectation. Or, we decide that we want to close the lagoon from the sea or focus on building better resilience in the lagoon system so that Venice can carry on similarly to how it is now. Currently institutions, academics, and experts are all acting on their own accord without communicating to work towards a common goal. Until we have this discussion agencies will continue to act individually and we will not know the final result until it is already too late.

When asked about potential obstacles that may thwart the success of proposals for the future of the lagoon, one participant stated without pause that the largest obstacle is “the government and the systems that are thriving in the way things currently are operating”. As may have been noted in the paper thus far, for almost every participant the most pressing obstacle in addressing every threat and challenge in the Venice Lagoon is the disconnect between the people and institutions that hope to preserve the city of Venice and its lagoon for the future. However, this disconnect is not only present between institutional actors; cultural and personal connections to the natural environment have been lost. Another participant echoed this sentiment stating that we can propose solutions to high waters, climate change, erosion, but we also need to provide and encourage opportunities for people, residents and tourists alike, to reconnect to the lagoon and the environment around them.

One participant, a professor of urbanism, remarked that greatest obstacle in solving the issues related to the Venice Lagoon is the disappearance of residents in the region and the local knowledge and skills they take with them when they leave. There are numerous highly accredited universities within the region that attract students from around the world, granting thousands of diplomas annually, and yet the city and surrounding region has not been able to keep them. The participant speculated that graduates of architecture, literature, economics, ecology, and law that spring from these institutions could promote new job development in the area. Their new perspectives could bring innovative ideas and a fresh wave of passionate people fighting for the lagoon and city.

5.4.11 Discussing the Future of Venice and its Lagoon

Many participants mentioned their concerns regarding the lagoon transitioning into a marine bay. One participant worries that accepting this fate is giving up— there are things that can be done to protect the morphological structure of the lagoon, although it requires intense

investment and innovation. Now that the Mose mobile barrier has been completed, we will have to adjust to a very different lagoon than one of the past. Pranovi stated that a managed system, one with barriers that can open and close based on high water predictions is a thing we are not prepared for. This solution was created as a response to solve one problem, flooding in Piazza San Marco and its basilica, without considering how such closures could influence ecosystem functions throughout the lagoon. There was also skepticism amongst all participants that this barrier was the best solution for the entire system; but as one individual suggested, immense amounts of money was invested in this intervention and so is impossible for the government to not use it now despite rising concerns from experts. It was suggested that the impacts of climate change will have monumental impacts on the Venice Lagoon over the next 10 years; however, currently we have no knowledge of the extent of the impacts combined with the Mose barrier.

When asked about their hopes for the future of Venice and its lagoon one of the most impactful responses was simply “I hope that everything survives”. Other participants hoped for the introduction of more nature-based solutions so that future generations (referencing all flora and fauna in the region) can enjoy the benefits of salt marsh habitats and fisheries for the years to come. A participant said “I envision the cultivating of seaweed to store carbon, maybe even use turbines to make the most of tidal flows instead of the Mose system to collect the current and make electricity for the city”. Others mentioned that they hope that in general environmental researchers will be able to increase their ability to deliver the right messages to politicians and decision makers. Some wish for multi-levels of governance to come together in collaboration to combat climate change, restore marshland, limit high speed boats, and regenerate the natural characteristics of the lagoon.

In response to the loss of inhabitants one interviewee said that they hope that when reviewing national or international laws impacting the region, subsidies aimed at attracting young people and families to reside in the region would be considered. Finally, one participant powerfully said that they “hope that Venice is a place again for local people and the restoration of local life. It’s not right to expropriate people based on the value of short-term income [tourism industry] over ecological protection, human protection, and cultural protection. People are the culture of the city and the people aren’t being protected”.

Chapter 6: Final Reflections

6.1 Concluding Remarks

When I started this research project, I had not expected to uncover so many complex dynamics influencing the management and longevity of the Venice Lagoon. It should be expected that in such a complex system, with so many stakeholders invested in the region, coming to an agreement on the best management practices and solutions for preserving the lagoon and the historic islands within it would not be an easy task. However, the degree to which conflicting interests cause friction in the region ran so much deeper than anything a literature and policy review could have possibly revealed.

The opening portion of this paper hoped to paint a picture of the Venice Lagoon, the geographic and ecological features that characterize it, the species that call the lagoon home, as well as threats to the well-being of the system. It was however through the interview process that a more colourful, realistic, and raw portrait of the lagoon was provided, especially when considering threats to the system. By hosting conversations with experts in various academic fields it was revealed that some of the greatest threats to the lagoon and its wellbeing are not just those that threaten the morphological structure or characteristics of the system. There are complex social, political and economic threats that influence the region in many ways— often becoming so intertwined and contentious that any attempts at resolution are paralyzed by the overwhelming need to untangle what can be seen as a twisted mess.

My policy review part of this paper hoped to analyze a sample of governing documents, frameworks, and authorities within the region to assess the degree to which they incorporate or acknowledge ecosystem services within the lagoon. Ecosystem services literature heavily suggests that inclusion or acknowledgment of these services could be instrumental in promoting sustainable management of the ecosystem and ensuring the preservation of the environmental integrity of the system. The policy review assessed whether documents referred to the entire lagoon or portions of it, if they failed to mention any of the services identified by academics, if they viewed the lagoon as a complex integrated system relating the bodies of water to the broader environment, and if they were all-encompassing documents. The hope was that by reviewing each document in this manner, opportunities could be identified for the adaptation of more sustainable and holistic governing documents and frameworks. The policy review was

effective as it identified gaps in legislation in regards to ecosystem management. However, if sustainable environmental management is not the priority of citizens, decision makers, stakeholders, advocates then who does these types of analysis? As interviews with stakeholders began, it became increasingly clear that while numerous policy reviews can be made, and legislative analyses can be conducted, until a broader discussion amongst all stakeholders regarding the future of the lagoon occurs, efforts to effectively manage the system are essentially futile.

So, one may wonder, how do we move forward and what is next for the lagoon? The final recommendations in the following section hope to provide further context to this question.

6.2 Recommendations for Moving Forward

The greatest call to action posed by participants in this project was the need for the community and region of Venice to decide as a collective what is expected from the Venice Lagoon in the years to come. As it was poignantly asked: Will the bucket list heritage site become a designated theme park capable of meeting the needs of tourists although devoid of a living lagoon system? Or will it become a living city once more with a robust local population dedicated to the holistic care and maintenance of the city and its lagoon as a unit? There are inherent trade-offs present for each choice, and of course, the future of the lagoon is not limited to just those two options. All the initiatives and policy campaigns can be planned and executed, but as the collection of expert opinions in this paper suggests, until a united front is achieved, institutions, academics, and advocates will continue to work towards goals that may overlap in final objectives, or in direct contrast with each other— perpetuating a never-ending battle within the lagoon. The disconnect and miscommunication between agencies, authorities, experts, industry leaders, and citizens, could be the death of the Venice Lagoon.

Not only does miscommunication risk the mismanagement of the system, it also produces gaps in the knowledge of the science behind the system. As mentioned in the paper, it is unknown what impacts the Mose system will have on circulation and various ecosystem functions within the lagoon. Ecosystem service mapping is still in its early stages requiring extensive resources and investments in order to paint inclusive pictures of the various dynamics present within the lagoon. Even within the same field scholars utilize different methodologies in their studies resulting in sometimes contradictory results. Sharing information between experts

and creating collaborative research projects are critical for establishing a robust knowledge of how the ecosystem functions. Addressing any existing gaps in the scientific knowledge of the lagoon in turn will advance the effectiveness of management activities.

The evidence compiled in this paper has resulted in the following recommendations that, in no definitive order, should be taken in order to ensure that the miscommunication between stakeholders no longer paralyzes efforts to protect the lagoon and the city of Venice:

- A survey should be conducted among those that rely on the lagoon to gain a deeper understanding of what their wishes for the future of the lagoon may be to identify the priorities of those most directly impacted by the health and well-being of the lagoon.
- A regional focus meeting comprised of decision- makers, members of various political parties, academic experts from various fields, stakeholders, and citizens should be organized so that a formal discussion on the future of Venice can be held.
- A simple rough model of the Venice Lagoon should be created borrowing methodologies from ecosystem service mapping and existing hydrological models. The model should reference the various ecological dynamics present within the lagoon, but be elementary enough that stakeholders from varying backgrounds could use the same model when assessing or predicting the impacts an action or decision may have on the entire ecosystem. This way, every actor in the region would be provided the same introductory comprehension level of the lagoon. Furthermore, as experts continue to research the lagoon, findings from all backgrounds can be submitted to the model to ensure its relevance. This would not only increase the sharing of information between academic fields, but also with decision-makers, stakeholders, and members of the public. In the past, models were utilized for specific academic purposes in which experts in an explicit field were solely able to use. Nowadays, user technology has significantly improved and experts have been able to create variations of models that efficiently synthesize information so that any member of the public can consume it. Such a model of the Venice Lagoon could be developed and then used as a tool within the regional focus meeting, to help guide conversation regarding management decisions within the lagoon. Based off this model, additional models projecting various futures for Venice and the Lagoon can be created in order

to stimulate discussion between stakeholders regarding which future they would like to work towards ensuring, or preventing. Academic institutions, such as the Ca' Foscari University of Venice could be charged with creating such model.

- At the time of concluding this paper the Venice Lagoon is currently at risk of being removed as a UNESCO World Heritage Site. Ultimatums such as these seem to be effective at mobilizing decision makers to take action in protecting the environmental integrity of the lagoon. Communication in the region must be improved in order to safeguard the future of Venice and its lagoon, and international organizations or authorities ought to have the power to demand that formal conversation is initiated in some capacity.
- A civil society organization should be established as an accountability measure to oversee the execution of management frameworks in the lagoon and provide continual reports on the status of the lagoon to all stakeholders and governing bodies.
- Additionally, a film or video based on Venice and the lagoon, the challenges it faces, and hopes for its future could be produced. A documentary, or similar format, could encapsulate the thoughts and opinions of stakeholders similar to, or based on the interview portion of this paper. This type of project could further encourage or incentivise stakeholders to engage in discourse regarding the future of Venice and its Lagoon.

Until a common conversation can occur, one temporary recommendation could be the encouragement of establishing sustainable tourism within the region. Ecotourism is a challenging prospect in a region that maximizes the tourism industry—but measures can be taken to educate tourists in hopes of promoting sustainable tourism. In one effort to educate visitors to Venice, the students from the University of Padua Rethinking Climate Change: The Venice Paradigm program created posters that had a QR code that tourists could scan using their phones. When scanned, the code directs tourists to a podcast that discusses the threats the city and lagoon face, as well as measures that visitors can take to promote sustainability. Educating tourists can extend further once they arrive in the city, including various initiatives that focus on educating tourists about their impact on the city and offer environmental offset programs to which they can choose to contribute. Additionally, organizations can continue to appeal to decision makers through

projects such as the WahV and VITAL collaboration that seeks to establish a carbon market based on restoration projects in the lagoon.

There are numerous actions stakeholders can take moving forward. To simply do nothing is to admit defeat. The lagoon has been a beacon of beauty and a legendary feature of the Italian landscape for hundreds of years; this paper recommends that we continue to fight for its future.

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Appendix

- 1) Can you tell me a little bit about your personal or institutional history with Venice and to the lagoon?
- 2) Do you feel the lagoon's health and well-being is related to your own health and wellbeing? If so, in what ways?
- 3) Do you have specific concerns regarding the health and wellbeing of the Venice Lagoon?
- 4) In your opinion, what are the greatest threats to the wellbeing of the lagoon, and the various ecosystems that reside in and around it?
- 5) In your opinion, are there feasible solutions or actions that can be taken to address the threats that the lagoon faces? If so, what are they?
- 6) For my research I am looking at the "Ecosystem Services" provided by the land and waters of the lagoon and its broader environment. Are you familiar with the term 'Ecosystem Services'? If so, what does this term mean to you?
- 7) To your knowledge what services and functions does the lagoon provide to yourself, to others, and to the general ecosystem?
- 8) What ecosystem services from the Lagoon do you rely on or use in your day-to-day life? This includes personal or industry related uses.
 - a. For experts and politicians, I would follow up with the following:
 - i. Sometimes, what one may view as an important function or service of an ecosystem, may not be considered the most valuable monetarily. I'd like to discuss this further. What ecosystem service(s) provided by the Venice Lagoon do you consider to be the most important?
 1. Do you feel that this/these important ecosystem service(s) is being adequately protected from the threats the Venice Lagoon faces?

- ii. To follow up, which function(s) of the Venice Lagoon ecosystem are the most valuable monetarily?
 - 1. Do you feel that this valuable ecosystem service is being adequately protected from the threats that the Venice Lagoon faces?
- 9) In your opinion/experience, what ecosystem functions or organisms are the most impacted by the current state of the Venice Lagoon.
 - a. In what ways are they being impacted?
- 10) Do you know what actions are being taken to protect these services? If so, what are they?
- 11) From your experiences and in your expert opinion, are there certain areas or regions within the lagoon that require more protection than others? A map of the lagoon can be provided.
 - a. If so where and why?
 - b. What additional measures of protection would you recommend for that area and why?
- 12) Is the current state of legislation and projects dedicated to the protection of the lagoon upholding this role adequately? If so, why do you feel this way?
- 13) Are you aware of any future legislation or projects dedicated to the protection of the lagoon? If so, what are they?
 - a. Do you feel as though these plans and actions will be successful?
- 14) When politicians, experts, or members of the public discuss the environmental protection of the Venice Lagoon do you feel that all aspects of the lagoon are being considered?
 - a. For example, do you feel that there are organisms, ecosystem functions, economic values, or cultural values, that are forgotten or overlooked when

environmental protection measures are planned and executed? How, or how not, and why?

- 15) Do you know of any opportunities for the public to contribute to the maintenance and sustainability of the lagoon?
 - a. If so, on a scale of 1-10 how would you rate the level of public participation through these mechanisms.
- 16) Do you feel as though it is possible for governing documents to maintain, and advocate for, the environmental integrity of the lagoon?
 - a. If not, why?
 - b. If so, what key aspects or functions of the ecosystem do you feel need to be considered in governing documents to ensure the environmental integrity of the lagoon is maintained?
- 17) What would you consider to be the biggest obstacle in solving the issues related to the lagoon? And why?
- 18) Should the threats to the Venice Lagoon persist at their current rate, where do you see the Venice Lagoon heading in 10 years from now, then 50 years from now?
- 19) Looking to the future, what are your hopes for the Venice Lagoon and the historic sites that lay within it?
- 20) Do you know of any other people or institutions that I should interview?