ABSTRACT

Title of Document: REGENERATIVE AQUACULTURE: DESIGNING FOR RESILIENCE OF THE CHESAPEAKE TIDEWATER

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The Chesapeake Bay is out of balance. As the effects of decades of overharvesting, overdevelopment, and pollution have taken their toll, tidewater communities are confronted with a loss of culture, livelihood, and the environment in which they live. This thesis seeks to reframe the problem of regeneration of community and environment, through the use of resilient design.

Resilient design is the process of designing for an uncertain at risk future. Through resilient design, architecture and aquaculture can be combined with food culture to foster stewardship of place. This thesis will explore interconnectedness of tidewater food culture, the waterman culture, aquaculture, and regenerative design in an effort to generate a holistic solution.

The final product will consist of a methodology of planning for resilience at a framework scale, and will also propose an architectural solution that combines educational facilities with commercial aquaculture, to foster stewardship and regeneration in the Chesapeake Tidewater.

REGENERATIVE AQUACULTURE: DESIGNING FOR RESILIENCE OF THE CHESAPEAKE TIDEWATER

by

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Foreword

The Chesapeake Bay is in Crisis. Once one of the most bountiful environments in the world, it has been reduced to a shadow of its former glory. Captain John Smith, when first exploring the bay, found an *"abundance of fish, lying so thick with their heads above the water, as for want of nets … neither better fish, more plenty, nor more variety for small fish, had any of us ever seen in any place so swimming in the water"*[1]

The Algonquin Indians who originally inhabited it called it "The Great Shellfish Bay."[2] It was an environment that's arguably the reason that the first European settlement in Virginia, at Jamestown survived, without plentiful seafood available, the colony surely would have not made it through the first winter. The navigable waters of the Chesapeake were instrumental in the colonization of Maryland and the northeast, settlers could push far into the continent simply by farming and trading their goods right next to the water. Later, during the industrialization of the Northeast, the waters of the Chesapeake were the salvation of communities, and instrumental in the industrial growth of northeast cities, such as Baltimore, Norfolk, Annapolis, and Crisfield, among many more.

The bounty of the Chesapeake was so great that it was able to sustain the people of the region for well over 200 years. As populations grew and the nation further industrialized however, the Chesapeake Bay was harvested at rates not seen before, and pared with other stressors, such as land loss and pollution, the

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[1] http://www.johnsmith400.org/journalfirstvoyage.htm

environment began to degrade. Decades of this pollution, overdevelopment, and overharvesting, among other concerns, have pushed the Chesapeake Bay out of balance.

Something needs to be done.

This thesis will propose a portion of a solution. To do this, this, the thesis will analyze the Chesapeake environment through the lens of Design Thinking. Looking at the environment holistically by taking into consideration many concerns simultaneously, it will be possible to generate a 'web of failure', and by extension it is possible to find the major stressors of the environment. Design thinking can also help us to deconstruct this web into areas of overlap, and help inform on potential design solutions. It will then recommend a solution that will be proposed after doing a careful analysis of local culture, cities, industry, and environment.

Any solution cannot be a fully holistic solution, of course, it is simply impossible for one intervention to solve all of the issues in any complex situation. But this thesis will propose a solution that will hopefully, unravel at least part of the web of problems of the Chesapeake.

Introduction

A necessary first exercise in this thesis lies in the analysis of the generators of the situation. In the Chesapeake Bay, there are numerous conditions, environmental, cultural, and ecological, that have led to the systematic failure of the region. Each of these issues, looked at independently, seems potentially solvable, but placing these issues in a web reveals the truth of the matter: That there is a high level of interconnectedness of the conditions that have led to this downfall, and that remediating just one concern will not be enough to mitigate these issues.

Figure 1: Problems and Their Generators: Illustration By Author

The figure above talks about some of these concerns. This is not an exhaustive list, but these are some of the more relevant issues to the problem of the Chesapeake Bay, and coincidentally are the issues that design (and the field of architecture) can touch. Many of these problems seem to have some overlap, so the next step is to look at these conditions as a network.

Figure two explores the interconnected network nature of these problems. What is revealed when these issues are put on the table simultaneously is the fact that many of the major concerns, as expected, tie directly into one another. Within this web, there are topics that are directly related to multiple other topics, which could be termed ‘first order problems.’ These include the inner ring of topics in the diagram pictured below, such as ‘fisheries collapse’, or ‘disappearing culture’. Outside of these, lie an outer ring of concerns, some of which are human-instigated, some of which are not. Fisheries collapse, for instance, can be tied to overharvesting, historical exploitation, and is linked to other first order problems, such as environmental degradation.

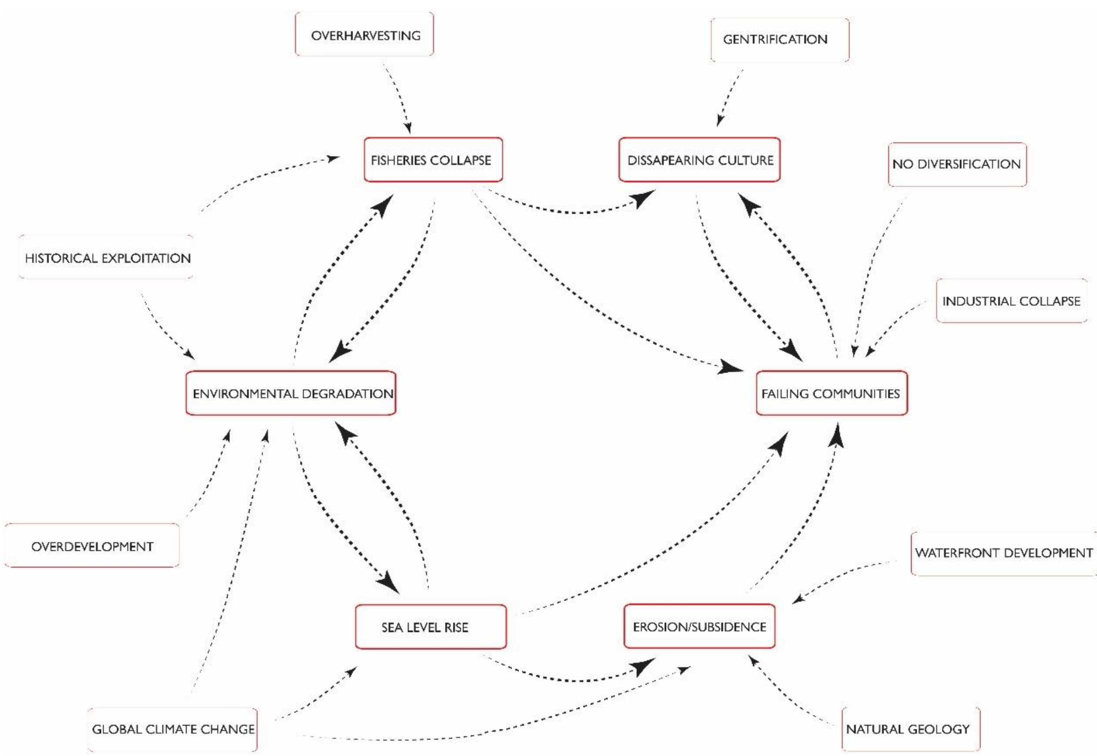

Figure 2: The Network of Failure Conditions: Illustration by Author

Figure 3 notes the topics that architecture and design can influence these issues, by removing the portions of the web that are outside the scope of the architectural realm, since architecture and design thinking cannot solve every problem. The topics that remain are therefore the regions of concern to the realm of design, as a tactical application of design strategies can be utilized to remediate some of these issues.

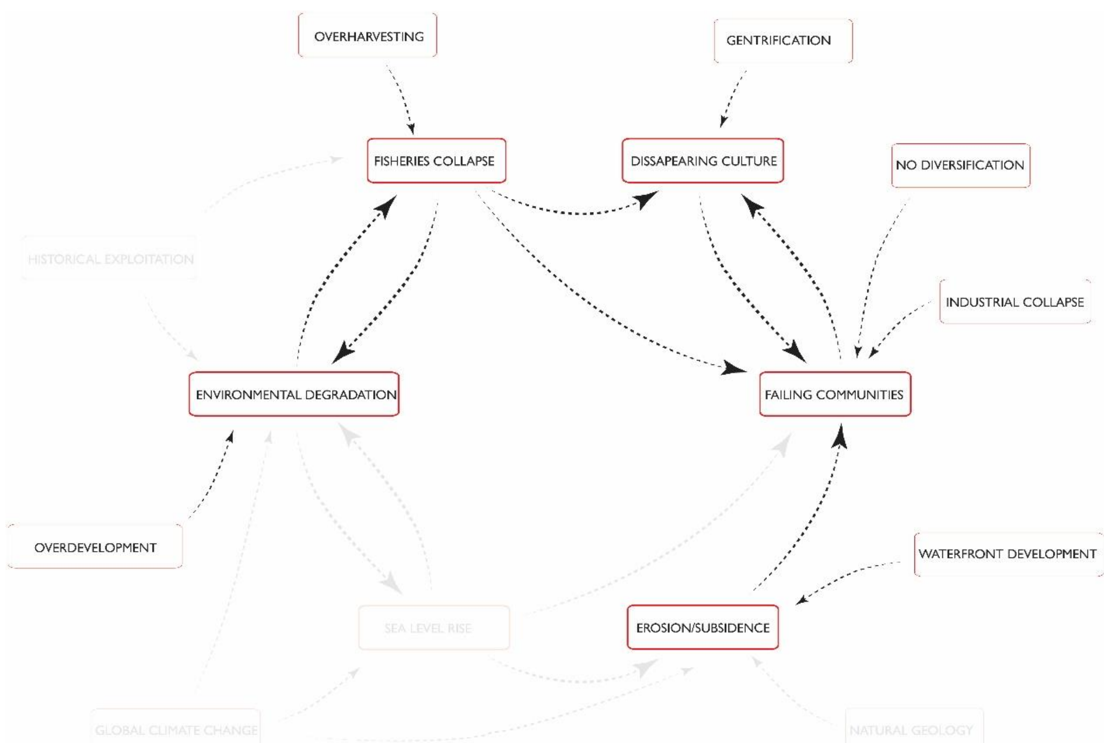

Figure 3: Designable Topics within the Problem Web: Illustration by Author

Finally, Figure 4 talks about a targeted focus area within this web. To get to the areas of most concern, (Fisheries Collapse, Disappearing Culture, Failing Communities, Erosion/Sea Level Rise), an area of focus is required.

Analysis of the web reveals where a critical path might exist - through the topic of failing communities. "Failing Communities", by this web analysis, is the only topic that is adjacent to every other area of concern that this thesis needs to address. Thus, this thesis needs to be community based. Shoring up a community, to prepare it for resilience to sea level rise, the environment, and the economy is the methodology that has become the critical path. This thesis will propose a solution that falls along this critical path.

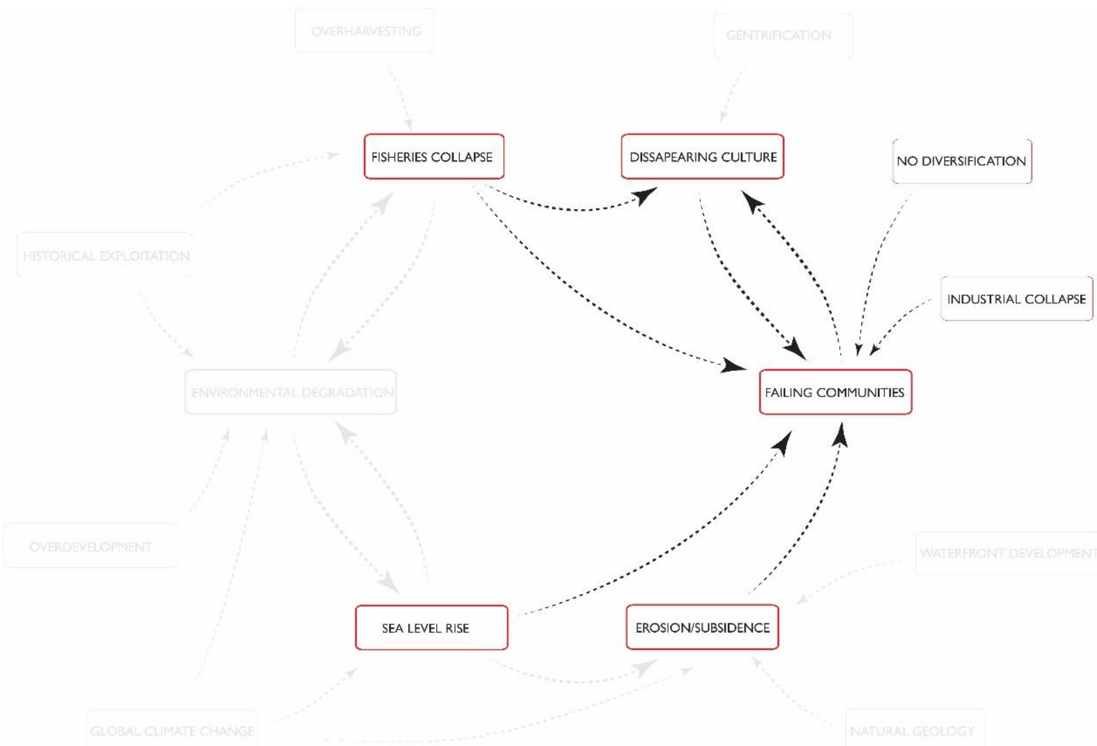

Figure 4: Focus Areas within the Web: Illustration by Author

This document seeks to utilize this methodology in order to understand this complex web of issues and failures that have led to the current state of the Chesapeake Bay. Further, it plans to utilize this background methodology to frame the inherent problems of site, and to allow for this frame to generate a lens of study.

Looking at the presumed 'web of failure,' it is evident that in order to get to the concerns at hand, (How do we revitalize failing communities), we have to by extension modify some of the inputs that have led to the failure conditions. This thesis seeks to do just that. A SWOT and in-depth analysis of the Chesapeake's challenges, history, and opportunities is needed to understand the best plan of remediation.

Throughout this thesis, this background data and focus will be used as a web of knowledge to make informed design solutions; since the best solution for a complex situation such as the Chesapeake bays degradation and future is one that is holistic. This thesis will seek to propose a resilient architectural system at both the local and regional scale, which will address the following concerns:

i) Sea Level Rise and Resilience to sea level rise

ii) Disappearing Communities and methods of preserving them

iii) Vanishing Culture

iv) Environmental Degradation and stewardship

Through the additional lens of 'regeneration', this thesis will propose a solution that brings these four key points together, at a scale of application that has not been seen in the Tidewater region. With a widespread adoption, this methodology can be proposed to be a 'handbook for regeneration,' where interested communities can borrow from these regional design tactics to ensure their survival in a world of changing livelihoods and environments. Further, this methodology will be adopted in a specific location – at the scale of the 'failing community', and then explored to an architectonic level of detail – what are the local implications and benefits of such a solution?

Acknowledgements

I’d like to thank my thesis committee, Amy Gardner, Brian Kelly, and James Tilghman, for all the guidance and help that they have given me through this thesis process. I would also like to thank Katarina Svensson, Danielle Olander, and all of my other friends who have acted as design critics and moral support over the last year. Lastly, I’d like to thank my parents, for making sure I’ve stayed healthy throughout this entire process.

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Geology of the Chesapeake Bay

Formation of the Chesapeake

Illustration 1: Chesapeake Bay, Water in Black – Illustration by Author.

The Chesapeake Bay in its current form stabilized around 3000 years ago. Given its nature as a shallow water estuary, its form is highly variable on the geologic time frame, as sedimentation and sediment deposit can have a large impact Its formation was generated through a multiplicity of geologic conditions, including the retreat of the glaciers from the most recent ice age, sea level rise from that ice age, the existence of the Susquehanna River Valley, the process of erosion and sediment deposit from the and additionally an impact canyon that was the result of a bolide meteorite that impacted the region around 25 Million Years Ago.[3]

18000 years ago, the retreat of the most recent glacier shelf carved a valley in the north south direction, now known as the Susquehanna River Valley.[4] This rift later became the major hydrological corridor of the Chesapeake, and the lower reaches of the Susquehanna River Valley became the largest portion of the Tidewater Basin.

The morphology of the bay is also generated by the Exmore Impact crater, which was formed by a bolide meteorite that impacted the region 25 million years ago. The Exmore Crater impacted the region near the mouth of the Chesapeake, overlapping the Susquehanna River Valley, and created a 85km diameter square mile depression centered near Cape Charles, VA, and the Chesapeake Bay-Bridge Tunnel. This crater created a series of ridges and depressions that helped to determine the flow of the river corridors in the south of the Chesapeake Bay, which include both the James and York Rivers.

[3] Bay Formation, Chesapeakebay.net
[4] Bay Formation, Chesapeakebay.net

Figure 5: Diagram showing the boundary of the Exmore Impact Crater

While this impact did not create the Chesapeake bay at this point in time, it did form a large depression, and series of ridges, created by the slumping of rubble and upthrust of the tectonic plates. The Exmore Craters primary impact was its generation of the form of the bay, by predeterming the course of three major river corridors, it allowed for a large enough volume of runoff to converge in one place.

As the sea level rose after the end of the most recent ice age, the Susquehanna River Valley and the slump of the Exmore Crater were inundated and the Chesapeake took its current geologic form.

Current Regional Geology

The Chesapeake Bay watershed traverses six states and 64,000 Square Miles of land, the majority of which is the watershed. Within this watershed, there are 19 principal rivers that feed into the tidal basin, with over 400 secondary estuaries feeding into the tidal basin [5]

The Chesapeake Bay is unique in the respect that it has one of the largest coastlines by length in relation to its area of water. The bay has an estimated 11,600 miles of coastline[6]

As a tidal estuary, a large swath of the environment and region is subject to a daily rise and fall of the depth of the water column. This range of tidal change varies by region. In the southern portions of the bay, Near Norfolk and the Chesapeake Bay Bridge-Tunnel, the difference in tidal depth averages around 3 feet. In the Middle portion of the bay (near Annapolis and the Bay Bridge), the variance in depth is around 1 foot, and near the headwaters of the bay (near the Susquehanna River and Havre De Grace), there is about a 2 foot change in tide.

On average, the Chesapeake Bay is a shallow tidewater estuary. The average depth of the Chesapeake (including tributaries) is around 20 feet deep. Since there are large regions of the Chesapeake watershed that average less than that 20 foot depth line, there is a wide spread of typologies of shallow water habitats, with much of the biodiversity of the bay being attributed to these shallow water habitats.

The shallow tidewater habitats and the swing of the tide has an additional effect of creating a large swath of 'intertidal zones' in the Chesapeake. Large regions of the Chesapeake Bay watershed are low slope regions, with an elevation that is only

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[5] Life in the Chesapeake Bay
[6] Regional Planning for a Sustainable America

a few feet above sea level. In these areas, the intertidal zone can be hundreds of feet wide. [7]

As with the changes in tide, which are partially based on the proximity to the mouth of the bay, the salinity of the Chesapeake is also variable by region. The Potomac Susquehanna, and James Rivers provide the majority (80%) of the volume of freshwater input into the bay. As such, there are regions of the Chesapeake Bay that are entirely Freshwater, and regions that have a similar level of salinity as an ocean environment. Generally, (but not always), the headwaters of each of the major tributaries are freshwater in nature, and outside the reach of the tides. At the headwaters of estuaries, the salinity is around 0ppt, Mid-bay salinity is around 15ppt. From the midbay region to the mouth of the bay, salinity gradually increases to that of the surrounding ocean. Overall, the average salinity of the bay hovers around 15ppt, but there is much local and regional variance. Salinity is heavily determinant on Within the water table, deeper salinities are present at the lower portions of the water table, as salt water is heavier then fresh water. Deeper waters in the Chesapeake range from 2-3ppt higher in salinity level.[8]

[7] Life in the Chesapeake Bay
[8] Life in the Chesapeake Bay

Figure 6: Chesapeake Bay Relative Salinity - Image by Author

The region is broken into a series of environmental zones, which are based on the salinity levels of the region. The main body of ‘Zone 1’ stretches to the northernmost regions of the Chesapeake, and is bounded roughly by the end of the Sassafras River. This area is considered a tidal freshwater region. ‘Zone 2’ is also bounded by the edge of the Sassafras River, and the lower reaches of this zone stretch into Virginia south of the Tangier Island and the Rappahannock River. The Salinity of Zone 2 Ranges from 1-18 PPT, The brackish waters (salinities of 1-10 PPT) are restricted to areas of Zone 2 around the Chesapeake Bay Bridge and North. Further South of The Rappahannock is Zone 3, which runs from the Rappahannock on the west to Onancock on the eastern shore. The Salinity of Zone 3 ranges from 18-30 PPT Salinity, and is the saltiest region of the Chesapeake.[9]

Further, the rate of salinity also varies as salt water advances up a river channel, tidal rivers lower in their salinity further upriver, and an individual river can consist of multiple salinity zones within fairly short horizontal distances.[10]

The wide variety of salinities in the Chesapeake allows for a great level of biodiversity. The types of flora and fauna that are able to reside in any bay habitat is determined by the salinity within the habitat type. The same habitat could have a different ecosystem, if they are located in different salinity zones.

Geologically and Geographically, there is also a distinct divide between the Eastern and Western Shores of the Chesapeake Bay. The tidal influence in the Western Shore of the bay is demarcated by the Atlantic Seaboard Fall Line, a geographic boundary where the intersection of continental plates created a vertical fault line. At this point, there are often rocky outcroppings and rapids on rivers, creating a natural boundary that varies between 15 and 90 miles inland. The fall line, where it intersects with the Chesapeake Bay, is the natural inland edge of the tidal regions of the Western Shore.[11]

The Western Shore is of a character of relatively steep changes in topography. In places like Calvert Cliffs, Maryland, the coastline of the Western Shore is almost completely vertical. This occurs because the geographic conditions in this region are older, and remnants of the Piedmont Plateau. The piedmont defines much of the

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[9] Lippson & Lippson, pp 6-7
[10] Lippson & Lippson, pp 6
[11] Chesapeakebay.net “bay geography”

Midatlantic Seaboard. It is composed of sandstones, shales and siltstones, which are dissolved and fractured by the bays water over time. Further inland, there is simply more mass of earth and rock to intersect with, and erode at the bays western edge. The shoreline in this region is in places quite unstable, cliff collapses can quickly modify the waters' edge.. It is estimated that the shoreline at Calvert Cliffs may have been as much as 3 miles further east when originally documented by Explorer John Smith.[12]

Illustration 2: Calvert Cliffs – Typical shoreline.

Other regions on the western shore of the Chesapeake Bay are less dramatic in character then Calvert Cliffs, but generally, there is a more pronounced topography in these places. There is, by extension, less of a risk from sea level rise and subsidence on the western shore, but the western shore is more subject to erosion, and geological collapse.

[12] Chesapeakebay.net "bay geography"

The Eastern shore of the Chesapeake Bay is very different than the Western Shore. In contrast to the hilly nature of the Western Shore, the eastern shore is almost entirely flat. The composition of the eastern shore varies from that of the western shore, it is composed of sedimentary rock, and unlithified sediments.[13] The highest elevation on the Eastern Shore is only about 100 feet above sea level.

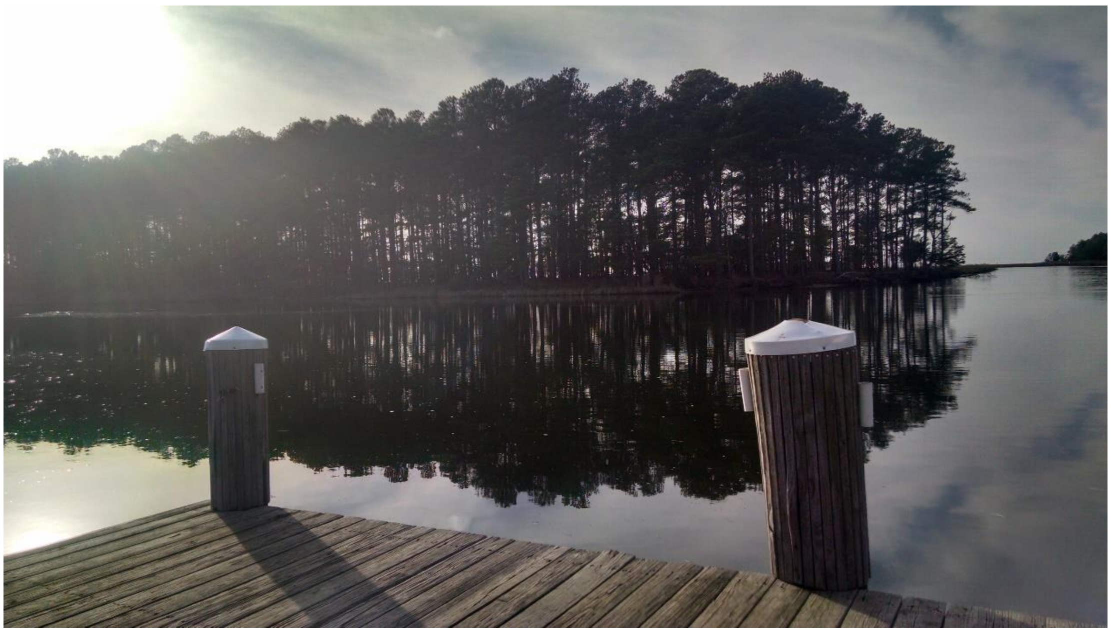

Illustration 3: A Typical Eastern Shore Environment, Crisfield. Image by Author.

The definition of the boundary of the eastern shore varies, but it can generally be considered the land that lies to the east of the headwaters of the Chesapeake Bay (The Susquehanna River), and the string of coastline that follows south from there. The Eastern Shore geographically is a portion of the Atlantic Coastal Plain.

The Eastern Shore is a peninsula bounded by the Atlantic Ocean to the East, and the Chesapeake Bay to the South and West. As such, the eastern shore is characterized by coastlines around its perimeter, and a 'waterfront' character of place is common. Beyond just the expanses of coastline, the character of the entire region

[13] Water Table Management in the Eastern Coastal Plain

can be considered ‘wet,’ since there are a large number of tidal and riverine estuaries that cut across the peninsula, as well as a number of saltwater marshes and swamps.

Principal Ecological Habitats in the Chesapeake Tidewater

The principal areas of habitat study for this thesis are the Intertidal Flats, Marshes, Shallow water environments, and oyster bars, but of course there are many other ecological habitats in the Chesapeake Bay. These four habitats, however, are environmental regions of note because they cover large areas and are critical to the health of the environment, and also critical to the Chesapeake fisheries, a plurality of which occurs in some of these environments.

Intertidal Flats

Within a Chesapeake estuary, the intertidal flats are regions of open mud expanses, which manifest as long and generally narrow stretches of shoreline. These areas are composed of either soft or hard bottom deposits of sediment, the hardness of the shoreline is dependent on the ratio of silt, mud, and sand. Intertidal flats occupy and often define the riparian edge, and create the boundary between land and water.

Illustration 4: An Intertidal Flat

Intertidal flats are named as such because they are subject to the changing of the tide. The area of exposure of the mud flats is dependent on the current level of the tide. This threshold region is home to both intertidal species, aquatic flora and fauna that are adapted for survival in the water and outside of the water for limited periods of time, and subtidal species, which are species that can survive outside of the water for short periods of time.

Species that reside in the intertidal flats are fairly limited as they must be adapted to both above water and below water conditions. Intertidal flats typically appear barren, as vegetative life has trouble establishing itself in these areas. The majority of activity in the intertidal flat occurs beneath the mud surface. Excepting scavenger species including waterfowl like the blue heron, and crustaceans such as blue crabs that intermittently occupy the surface, most fauna in the intertidal flats have adapted to subterranean life. The majority of these species consist of varieties of worms, but also include crayfish and clams.

Clams are probably the most well-known species that reside within the intertidal flats, and while clams are not a major cash crop in the Chesapeake Bay region, (only accounting for thousands of bushels annually, not millions), they are the most commonly harvested animal life in this region. Intertidal flats are common in both the northern and southern regions of the Chesapeake, but clams and clamming typically only occurs in the southern reaches of the bay, where the salinity is higher.[14]

The habitats beyond the intertidal flats are typically slightly deeper water areas, and can include marshes, areas of shallow open water, and oyster bars/flats.

Wetlands

Wetlands are defined as any region containing swampy environment, marshes, or another type of land region that is sometimes or always inundated with water.[15] Similar to the intertidal flat, which occupies the boundary between land and water, the wetland can also play this role. Wetlands are a transitional zone between riparian uplands and shallow water habitats. The boundary between a wetland and the uplands are often not defined with a hard line, wetland areas are subject to the ebb and flow of the tide just as the intertidal flats are.

[14] Lippson & Lippson, pp 51-72
[15] Lippson & Lippson, pp 185

Illustration 5: A Chesapeake Wetland – Image by Author.

Wetlands are variable in range of salinity, and also in the rate of tidal influence. Within the constraints of salinity and tides, the form and rate of biodiversity of any individual wetland is highly dependent on the character of the local site, where the rate of flooding, waves, wind, and elevation above sea level all have a large effect on the overall form and formation of a wetland.[16] Freshwater wetlands have a higher rate of biodiversity than saltwater wetlands.

Since there are so many factors that determine the typology and status of any wetland, they are naturally a very fragile ecosystem. Wetlands are more prone to erosion, subsidence, and also by factors of pollution of the environment.

Wetlands act as living filters in the Chesapeake Bay, the composition of plants and density of flora in these areas allows for the wetlands to function as a sponge.

[16] Lippson & Lippson, pp 190

They are able to remove and utilize some organic chemicals and pollutants.[17] Additionally, wetlands act as a natural barrier to erosion, their location within the transect of land to water (on and offshore on the riparian boundary) allows them to capture sediment and increase the local rate of sediment and silt deposition.

Typically, wetlands are situated within an estuarine boundary, successful wetland regions often are near a tidal stream that can feed nutrients and sediment into the environment. Marshes are further broken into smaller streams and channels within the wetland, which act as natural transportation corridors.

The rate of biodiversity in the wetland is larger than the biodiversity rates in other Chesapeake Bay habitats. The nutrient inflow into these regions is greater, so the productivity of these regions by extension has a higher natural carrying capacity.

Wetlands are broken into two general categories in the Chesapeake Bay, which include freshwater tidal marshes, and saltwater marshes.

Tidal Freshwater Marshes occupy the low salinity areas of the Chesapeake. They have a higher level of biodiversity than saltwater marshes. The character of a freshwater marsh is differentiated by the plant species extant in the marsh. Freshwater Marshes consist of emergent species, which are plant species that are able to grow directly within the water. Typically the centers of the marsh include broad leaved plants such as water lilies. The edges of the shore in a freshwater marsh are covered with reedy grasses, and other riparian buffer plants that are less tolerant of total immersion of water.[18]

[17] Lippson & Lippson, pp 182
[18] Lippson & Lippson, pp 183-185

Since the tidal freshwater marshes have some of the highest levels of biodiversity in the Chesapeake Bay, they are often located near critical spawning grounds of estuarine fish. Much of the concerns about the viability of the Chesapeake Bay ecosystem can tie back to concerns of the freshwater marsh environments, without an appropriate spawning area, these fish species simply cannot propagate.

In higher salinity regions, tidal freshwater marshes give way to salt marshes. Salt marshes are a unique ecosystem that is allowed to exist in the bay area due to the mixing of salt and fresh water. Over long periods of time, salt marshes grow in area through the accumulation of peat bogs, which are created by the process of decay of grasses and other biomass in the environment. These deposits of peat act as a sort of shoreline buffer, and are an indistinct boundary between land and water.[19]

Salt marshes are subdivided into both “Low Marshes”, and “High Marshes.” This distinction is made by the rate of immersion that they experience. Low salt marshes are flooded twice daily by tidal forces. These areas that are under the influence of the tides are critically important to the health of the bay and ecosystem since they are able to ‘filter’ water into and out of the tidal marshes at a controllable rate. Intermittent estuaries also provide habitat for many species, the intermittent connection to the broader environment gives ponds a level of seclusion and shelter from predators. Salt marshes are home to dense populations of fishes, and also to blue crab, which subsist on the high rate of smaller creatures in the marsh.

High marshes are similar to low marshes in composition, except they are not subject to daily fluctuations in tide. High marshes are wet environments that are

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[19] Oceanservice.Noaa.gov

elevated above the typical high tide line. Water typically only inundates these environments irregularly, in periods of storm surges, or by the force of wind. Generally, they act as an extension or continuation of the tidal saltwater marsh. Species in this area are adapted to both aqueous and land based habitats, and many spawn in the water, and adapt to dry land as they mature.[20]

Shallow Waters

Further out from land are regions of shallow water. In the context of the transect of land to bay, shallow water regions typically occupy spaces between the marsh and the oyster bar. Unlike in the intertidal flats or marsh environments, shallow water environments are always inundated with water. Shallow water environments are by nature of an indeterminate boundary, since the character of the deeper water zones is similar and on a loose continuum. Typically, shallow environments are defined as areas where the water depth is less than 6-10 feet deep. The quality of shallow water environments, like in the marshlands, are very dependent on current regional weather and climatic conditions. Shallow water zones are subject to intense water quality changes in adverse weather, as sediment and silt (as well as human created pollutants) wash directly into these zones. Further, storms and freshwater runoff from rivers channels lower salinity waters into these environments, and the shallow water depth in these areas cannot tolerate large influxes of freshwater. Any

[20] Lippson & Lippson, pp 190-195

storm system is an intense stressor in these environments.

Illustration 6: A Shallow Water Environment. Image by Author.

The most visibly present species in the shallow waters are various species of fish, crab, and waterfowl. Of note are the various species that are currently harvested for sport and commercial use, including Rockfish, The Chesapeake Oyster, and also the Blue Crab.

Many of these aquatic species are at risk. Recently, the population of rockfish and Blue Crabs has declined, partially due to the increasing level of environment stressors such as silt deposition and nitrogen influx, which reduces the spawning capacity of the shallow water environment. Additionally, the degradation of marsh habitat that can help to mitigate the volume of siltation and pollution that comes with any storm decreases the overall resilience of the shallow water environment.

Oyster Bars

The final habitat of note to this thesis is the oyster bar. Oyster bars occupy a region of the bay that is the furthest out along the land to water transect. They are often the defining line between shallow waters and open water environments, but can sometimes stretch to shore and be completely surrounded by other types of habitat.[21]

Oysters, like other brackish water species, are dependent on local and regional conditions for survival. The ideal habitat for an oyster includes a level of salinity between 7 and 30 PPT. Since the salinity of the Bay is highly variable based on distance from the mouth of the bay, the depth of ideal oyster habitat varies. Further north in lower salinity environments, oysters tend to reside in deeper waters, and are less likely to break the water's surface.

Historically, oyster bars were one of the most prevalent organisms in the Chesapeake, and bars were very large and often broke the surface of the water in high salinity environments.[22] They were of such a large scale that they were marked on maps as navigational hazards. Today, oyster bars can more aptly described as 'oyster flats.' Historical dredging and oyster overharvesting has led to the remaining oyster habitat in the Chesapeake resembling more of a flat skim of oyster on top of a muddy surface.[23]

[21] Life in the Chesapeake Bay
[22] Lippson & Lippson, pp 218-219
[23] Chesapeake Oysters

Figure 7: Restored Oyster Reef At the Virginia Coast Reserve (Outside of the Chesapeake)[24]

Oyster bars (in their historical formation) are large biological constructs, which are formed as massive masses of shells adhered together. Oyster bars tend to hug the coastline, and can also be found in regions with shallow water that is not necessarily tied to the coast. They take the form of large reefs with an amorphous shape, and in periods of low tide could break the surface of the water. [25] In the Chesapeake Bay, oyster reefs are created when oyster spat adheres to an existing reef. Since much of the bottom of the Chesapeake is a muddy silty surface, the majority of oyster spat can only attach to extant oyster reefs. As an individual oyster has a lifespan ranging up to 20 years, and can grow up to an inch a year, historical reefs and the reefs that existed upon discovery and colonization of the bay must have been massive.

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[24] http://www.mcatoolkit.org/Field_Projects/Field_Projects_US_Virginia.html
[25] Livie, pp 217

Oyster bars are also a notable habitat because the nature of their location and structure allowed them to operate as natural storm protection and breakwaters. Marsh environment and the shoreline behind the marsh is protected to some extent by an oyster bar, and storm erosion may be mitigated by the presence of oyster breakwaters.

While the oyster bar implies a monoculture of oyster, there are in fact a number of species that live within the oyster bar. The majority of these species are other mollusks, mussels and other shelled creatures attach to oyster bars. Additionally, there are crab species, such as the oyster crab and mud crab, which feed on oyster bars and are one of their primary natural predators.

Environmental Crisis in the Chesapeake

Subsidence, Erosion, and Sedimentation

Geologically, there is a pattern of subsidence in the Chesapeake Bay that has been occurring since the end of the last ice age, around 18000 years ago. As the ice shelf retreated north, the land in the tidewater began to subside. The ice shelf that covered the region north of the Chesapeake Bay was of an immense weight that pushed the tectonic plate down, and by extension the ground level in the Chesapeake Bay area was thrust upwards. When the ice shelf retreated, the ground was allowed to subside. This process has been occurring since the end of the last ice age, and has been documented since the earliest English settlers started colonizing the region. Even without any other environmental threat factors, subsidence has been slowly sinking land in the Chesapeake that is typically only a few feet or even inches above sea level.

This pattern can be observed through the analysis of historical maps. It is estimated that over 400 bay islands, many inhabited, have been lost to subsidence since the 1600's.[26]

Figure 8: Map, 1893 Survey of the Chesapeake Bay, showing islands. Courtesy US Coast Survey

Erosion is a closely related process to subsidence, but it is a process that operates at a more local scale. Every storm and high tide that comes into the Chesapeake has an influence on the alignment of the coastline. The Chesapeake Bay consists of silty and muddy bottoms, and this same type of soil is what composes

[26] Chesapeake Bay Foundation - http://cbf.typepad.com/bay_daily/2010/10/the-last-house-on-holland-island-has-fallen-the-iconic-wooden-home-which-became-a-symbol-of-the-impact-of-rising-sea-level.html

many of the islands and coastal plains the surround the bay. This type of soil also happens to be easier for storm systems to move.[27] As any hurricane or large that enters the Chesapeake has shown, storm systems are able to quickly alter the entire coastline. Erosion is also facilitated through river outflows. An example of this can be seen at Flagg Ponds Nature Park, in Calvert County, Maryland. Here, the beach has been moving steadily outwards, and changes in shape yearly.[28] The type of soil and silt in the region is able to accelerate this process, compounding the threat of subsidence by nature of quickly moving material elsewhere.

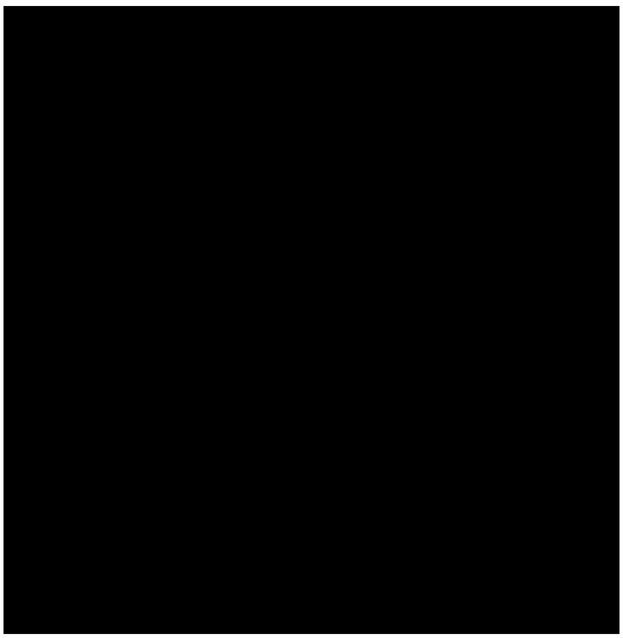

Figure 9: Sediment Migration at Flagg Ponds Nature Park

Flagg ponds one such source of sediment influx into the bay. While sedimentation is partly a natural process, the impacts of farming and development

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[28] http://www.washingtonpost.com/wp-dyn/content/article/2009/07/17/AR2009071703400.html

have tipped the balance, and the amount of sediment that enters the bay is beyond the mitigation capacity of the environment. (see fig 5)

Figure 10: Sources of Sediment in the Chesapeake - Courtesy of the CBF

Sea Level Rise

Compounding this threat is the more recent concern of sea level rise. As the glacial ice caps continue to melt (and as the influence of human induced climate change speeds this process), Natural accretion processes that were able to stabilize the rate of shoreline loss through new shoreline creation are not able to compete with global sea level rise. While the global average for sea level rise is 1.8mm per year, the effects of global warming have raised the average relative sea level rise in the Chesapeake Bay is 3.9mm per year.[29] This equates to about a half a foot every 30 years, or a foot every 60. Compounding this threat are the development patterns in the

[29] Land Subsidence and Relative Sea Level Rise in the Southern Chesapeake Bay Region

region, where there is a tendency to build on the waterfront and to remove marshes and dredge nearshore regions. While the fact that islands and landscapes change over time is a valid counterpoint, the rate of change and additional stressors on the environment are changing this balance. Many miles of the eastern shore shoreline in the Chesapeake bay are low lying environments, and the projected land loss from this is huge. The diagram below illustrates this.

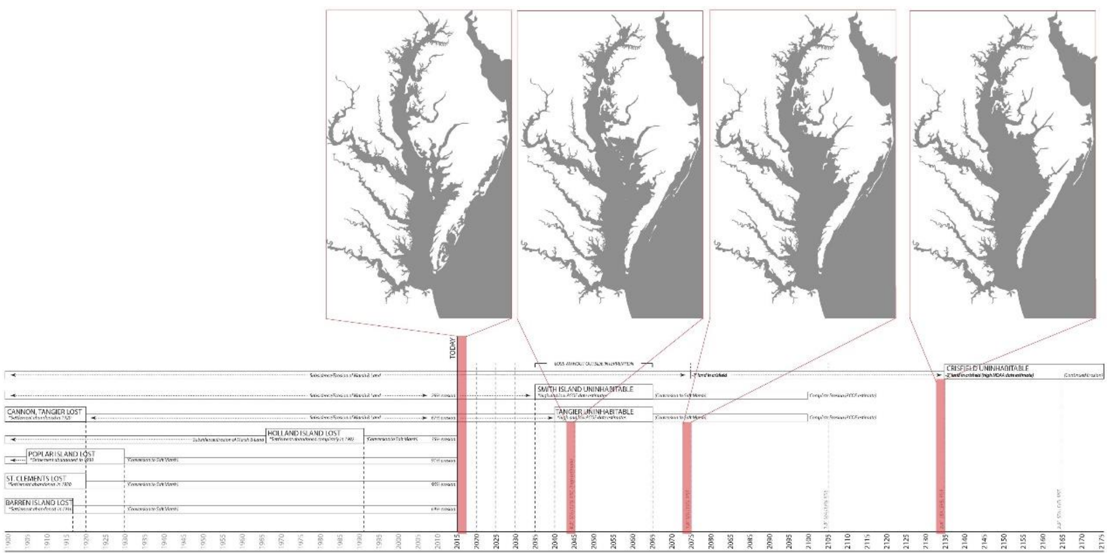

Figure 11: Sea level rise projections and timeline in the Chesapeake. Image by Author.

Pollution and Environmental Degradation

Additionally, there is the looming threat of environmental degradation in the Chesapeake. Since its discovery in the 1600's, the quality of the Chesapeake ecosystem has steadily declined. In 1999, the Chesapeake Bay received a 303d listing from the EPA per the guidelines of the Clean Water Act. This listing means that as a whole, all of the tributaries of the Chesapeake Bay are not meeting acceptable water quality requirements, and that the water quality is impaired by pollutants.[30]

[30] Environmental Protection Agency

In the Chesapeake bay, the primary sources of pollution are nitrogen, phosphorous, and sediments. Of these, nitrogen has the largest impact. In the Chesapeake Bay, nitrogen deposition is composed of a plurality of atmospheric (33%) deposition, and the remainder is from agricultural activities, 26% percent of nitrogen inflow comes from chemical fertilizers, and 19% comes from manure. The remainder of the nitrogen influx into the bay is generated by municipal waste water and septic systems.

Figure 12: Nitrogen and Phosphorus Sources in The Bay - Courtesy of the CBF

The Chesapeake Bay Foundation states that "*too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle*" further, they claim that "*increases in algae harms the water quality … habitats, and decreases the oxygen that fish and other aquatic life need to survive*"[31]

The multiplicity of sources of pollution makes this problem difficult to handle. It is simply not possible to curb one source of pollution entirely. Each source must be

[31] http://www.chesapeakebay.net/indicators/indicator/reducing_nitrogen_pollution

slowly mitigated, and has to occur at a rate that is faster than the population growth rate of the region which might increase stress on the environment.

Habitat Loss

Increasing development in the region has also led to an unprecedented increase in habitat loss.

Current Environmental Preservation and Restoration Efforts:

Pollution Control

Simply put, Reduction of pollution sources is the solution to the pollution problem in the Chesapeake Bay. The EPA currently has a series of 'maximum load' levels set in place, which set limits for the amount of each individual pollutant entering the bay. While this is an effective method, it does not have any sort of hierarchy. The Chesapeake Bay Foundation proposes that within this framework, a new hierarchy be added to generate a better set of metrics that can begin to regenerate the environment.

They propose splitting the metrics into three categories:

i) The bay ecosystem health index

ii) The restoration progress index

iii) The ecological footprint index

With all of these individual indexes having established restoration goals and metrics and method of implementation, these indexes could be judged based on a 'percent of completion of goal,' with progress measured by ecosystem health indicators and environmental quality analysis. The CBF proposes that this model creates clear progress reports, and makes a solution tangible. The EPA strategy of 'maximum load' does not do this.[32]

Habitat Preservation

Habitat preservation is a more tangible goal to achieve, because unlike with pollution and effluent management, there is a visible component to habitat preservation. A visitor can tour a wildlife refuge, or a restored stream, and can understand that this is a special place set aside for the health of the ecosystem. This is a very powerful notion, because these types of environments have the ability to mobilize individuals to care more for the bay. Some

Habitat preservation is also perhaps the most efficient method of creating effective environmental buffers. It is much easier to preserve an environment that is extant then it is to create one from scratch. The CBF breaks habitat preservation into a number of core areas of concern. The two that this thesis will focus on include wetlands, and oyster reefs.

The primary threats to wetlands are development, invasive species, and sea level rise. Since wetlands are able to soak up storm surges and runoff, removal of them can have a large impact on the stability of the environment inland. Restoration of wetlands is broken further into a series of actions based on the amount of effort required. The simplest method of restoration of wetlands is establishing protection for them. This can take the form of land acquisition, and can also exist in the form of

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[32] Chesapeake Bay Foundation

easements. Beyond simple protection, there are additional (more intensive) steps of rehabilitation, which restores the function of a weakened wetland, Enhancement, which is the artificial improvement of a wetland, and reestablishment. Reestablishment of a wetland involves restoring one to its former historic state, when it may have been drained or compromised in the past. The most intensive method of wetland restoration is wetland establishment, which involves creating a wetland where there was never previously one.

The Chesapeake Bay Foundation established in 2010 a goal to restore 85000 acres of wetland in the watershed on existing agricultural lands Currently, they estimate that they are at 7% of that goal.[33] The Chesapeake Bay Foundation proposes that this wetlands restoration goal can be accomplished through land acquisition and easements.

Habitat preservation also exists in the form of the creation of oyster reefs. The filtration capacity of the oysters in the Chesapeake used to be able to filter the entire bay in a number of days, but the scale of degradation of the oyster bars has increased the length of this process to over a year in length.

Restoring oyster reefs is a strategy that recreates habitat for oysters and other fish and shellfish, and allows for the increase in the oysters critical filtration capacity. Oyster reefs are rebuilt using oyster shell and other alternative materials, which allow oyster spat to attach and grow on their surface. Rebuilding oyster reefs has the potential to increase the overall oyster population, which In turn can create a positive feedback loop for the health of the Chesapeake Bay. Cleaner waters increases the ease

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[33] http://www.chesapeakebay.net/indicators/indicator/restoring_wetlands

of survival for the individual oyster, so the targeted restoration of oyster reefs allows for more and more oyster spat to reach maturity.[34]

The CBF has the goal of restoring oyster habitat in 10 estuaries by 2025, and there are further plans to expand this after that goal is achieved.

[34] http://www.chesapeakebay.net/indicators/indicator/restoring_oyster_reefs

Chapter 2: Chesapeake Culture

The Chesapeake Town

The cultural environment is perhaps as rich as the natural environment in the Chesapeake tidewater. Without such a rich natural environment, which sets the ground for the creation of a sense of place in the environment, a strong cultural environment would have had more difficulty in becoming established. Since cultures are generated through their environments, an analysis of how people inhabit and utilize the environment is the most effective method of understanding culture.

Before the generation of the 'waterman culture,' that will be detailed later, there was a preexisting cultural environment in the Chesapeake Tidewater Region, that was perhaps more informal. The tidewater was settled in the early 1600's by the English, with large tracts of land being settled as plantations, the plantation masters utilizing the coast as an easy method of moving goods to sale both domestically, and internationally.[35] As these plantations depleted the soil quality and needed to diversify, they developed into settlements that began to also harvest the abundant fisheries.[36] This cultural environment is perhaps best understood by the layperson through the lens of the watermen, who are often viewed in the same light as cowboys in the west. [37] To some, the watermen are revered as outriders, and exist as one of the few remaining hunter-gatherer lifestyle in the modern world. [38] Unsurprisingly, there is a lot of literature that focuses on documenting this identity. Much of the cultural

[35] http://www.milaminvirginia.com/Links/HOUSES/colonial_virginia_and_maryland_houses.html
[36] http://www.milaminvirginia.com/Links/HOUSES/colonial_virginia_and_maryland_houses.html
[37] Dancing with the Tide, Blackistone
[38] Blackistone

identity of the region is centralized around this archetypical character. However, this is by far not the only artifact of the Chesapeake Tidewater culture. The identity also manifests itself through a shared desire to be more like this character, and people purchase waterfront homes or boats and slips in order to escape into this mentality.

Since so much of these qualities are also location based, the cultural identity and some historical context can also be extracted through the typology of waterfront towns in the region. Their architecture and planning closely tied to culture, acts as an artifact of the same environmental conditions that created the watermen.

Town Development and Planning along the Coast of the Chesapeake Bay

On the coast of the Chesapeake Bay, many towns and cities can be described as exhibiting qualities of the Tidewater Culture. While some towns have lost most of this sense of culture through diversification of later development (See Georgetown in Washington, DC, or Baltimore in Maryland), the majority of these towns still have enough of an ‘original’ design intact that they can be analyzed and documented to extract key principles of this original regional building culture.

This analysis reveals that towns can be broken into categories. Notably there is a distinction of form types that is based on localized geographic location, and there is also a distinction of type based on their current and historical uses.

Town Form based on Geographic Location

A visual analysis reveals that there are three general typologies of waterfront town development in the Chesapeake Tidewater. These consist of the River type, the Peninsula type, and the Island type. If it is assumed that all of these typologies were generated as a side-effect of a necessity to fish and gather, aspects of the tidewater and waterman culture and elements of tidewater town planning can be extracted from them.

In the River Type, the town is situated either at the mouth of an estuarine river, or placed some distance upstream. (They could perhaps be subdivided into Delta and Midriver types.) The distance of this placement upstream varies, but they are never above the highest navigable point by water. Some examples of towns that demonstrate this typology include Chesapeake City, MD, Chestertown, MD and Crisfield, MD.

Figure 1: River town of Chesapeake City, MD. Image courtesy of Google Earth Pro

It can be speculated that river towns developed where there was a need to push goods and harvests further inland, or when there was a need to bring goods from further inland towards the coast. Before the region was serviced by roads, onshore and offshore harvests were transported by boat, so access to water was critical.[39] Currently, river towns operate as crossroads. As vehicular roads were built, routes were designed to link these inland towns together.

River towns are also perhaps more successful at diversifying industry away from harvesting. Visual analysis reveals that the surrounding context is often farmland, it can be speculated that many of these towns were situated far upriver in order to take advantage of both the estuarine environment, and the agrarian environment.

Another typology of waterfront town development that can be seen is the peninsula type. The peninsula type can be described as a town that is placed some distance down a peninsula. These towns are often narrow and linear. In many cases, they are situated in a manner that takes advantage of multiple estuaries, so more points offshore can be accessed from the same spit of land. Some examples of towns that demonstrate this typology are Hoopersville, MD, St. Michaels, MD, and Piney Point, MD.

[39] Michener

Figure 2: Peninsula town of Piney Point, MD. Image courtesy of Google Earth Pro

Peninsula type towns are more successful at accessing water than the river type town but are less successful in terms of expansion. Many towns are situated on very narrow peninsulas, often only wide enough for one street and houses on one or two sides. These towns are not able to expand outside of a linear manner, and have difficulty sustaining themselves after years of sustained poor offshore harvests. It is also notable that since these areas are so squeezed for space, they tend to only exist in terms of the offshore harvest. There is not enough abundant land area to allow for diversification into agriculture.

A third general typology of town that can be observed is the Island Type. Perhaps the most interesting because of their highly isolated nature, island towns are situated such that they have the ability to access fishing areas in all directions. The distance of these islands from the shore varies, with some only being a short distance from the shore, such as what can be seen in Tilghman Island, MD, others, such as Smith Island, MD and Tangier, VA are further away from the coastline. Generally, island communities that are closer to shore become serviced by bridge, and only a few outlier communities remain completely isolated from land.

Figure 3: Island Town of Tangier Island, VA. Image courtesy of Google Earth Pro

The island type town seems to be the most endangered type in the Chesapeake tidewater. Some islands, such as Holland Island, which once had thriving communities on them, have been completely erased by erosion and sea level rise over time.[40] There are over 400 recorded islands that have been lost to erosion and subsidence since initial exploration in the 1650's. [41]

These typologies are important because they illustrate graphically
The character of a place. While much of the sense of place is generated through the street level, the framework scale developments as seen from the air become just as important. Overall, these typologies can be used to illustrate some of the original site

[40] Chesapeake Bay Foundation - http://cbf.typepad.com/bay_daily/2010/10/the-last-house-on-holland-island-has-fallen-the-iconic-wooden-home-which-became-a-symbol-of-the-impact-of-rising-sea-level.html
[41] http://www.chesapeakequarterly.net/sealevel/main8/

conditions, and some of the problems that come inherent with developing along a coastline.

Organic vs Planned Towns

Within a matrix of River, Peninsula, and Island type towns, it can additionally be surmised that there are two methods of town planning in the Chesapeake Region, which focus on methods of planning for growth. These are the Organic (unplanned) town, that seems to grow with the lay of the land over time, and the planned town, which is designed for a maximum extent of growth at its inception.

With some exceptions, many of the organic towns are towns that were originally based seem to be towns that were centralized on commercial fishing, which can be termed "Working Towns." In contrast, planned towns are towns that were more likely to be artificially created, such as in the case of Tolchester Beach, MD, where the town existed as an amusement park and small community. In this case, it was more efficient to create a gridded community. These can be considered "Pleasure Towns."

Working towns vs. Pleasure towns

An immediately evident difference in town typology can be seen in this distinction between Working towns and Pleasure towns. There is not a hard cutoff when it comes to what is considered a Working town, and what is considered a pleasure town, since many elements of working towns can be seen in pleasure towns (and vice versa.) It is important to note the difference when it comes to understanding the typology of town, and how there are different series of draws to the region. Gentrification can often modify a working town into a pleasure town, but this is not always the case. Both typologies need to be analyzed, as together this manifestation of form generates a Tidewater Identity.

General Characteristics of working towns:

The working town, or a town that's reason for being is focused on the harvesting of fisheries, are as previously mentioned, some of the earliest towns that developed along the Chesapeake Bay. In general, they are defined as towns with a heritage of harvesting the fisheries.

Working towns usually include commercial infrastructure to support the fisheries. These programmatic elements include either a centralized marina, or a series of distributed docks and wharfs. Additionally, a crab shanty or holding areas for marine harvests can be seen in many cases. The third major component of a working towns' commercial infrastructure is the packing and processing facility. These are less common than they were in the past, as smaller facilities have combined over time, but they are still important to the survival of the town. (Without processing facilities there would be no means of profiting on commercial fishing.)

Figure 13 Ewell, MD, showing all manner of commercial activity (in black) - Image by Author

The arrangement of the docks comes in two main categories: The Docks are either dispersed from one another, or they become conglomerated, in the form of a central town marina. They are placed on the water's edge, and often take advantage of natural coves in the landscape for environmental protection. In the case of dispersed docks, they are often privately owned, for the use of one or two watermen.

It is important to note that the location of the dock and holding facilities do not need to be adjacent to the home, or even to the land. In extreme cases of erosion, such as in Tangier, VA, the commercial activity happens entirely offshore.

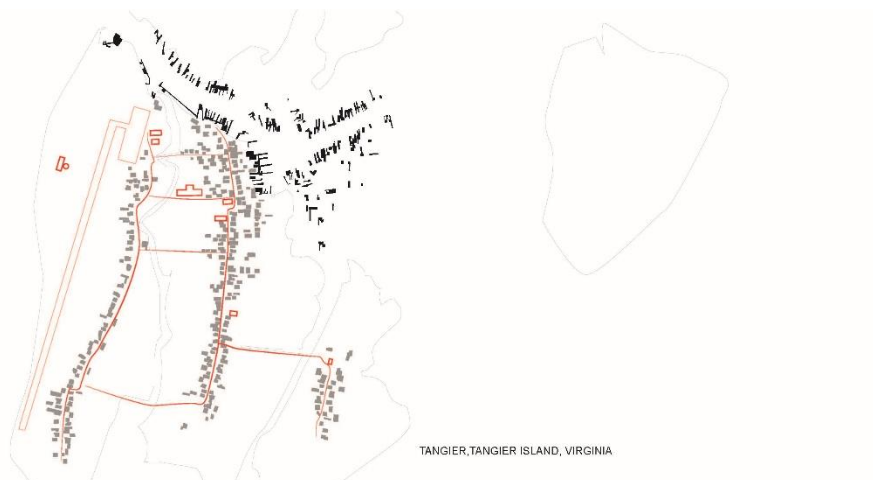

Figure 14 Offshore Commercial Activity – Image by Author

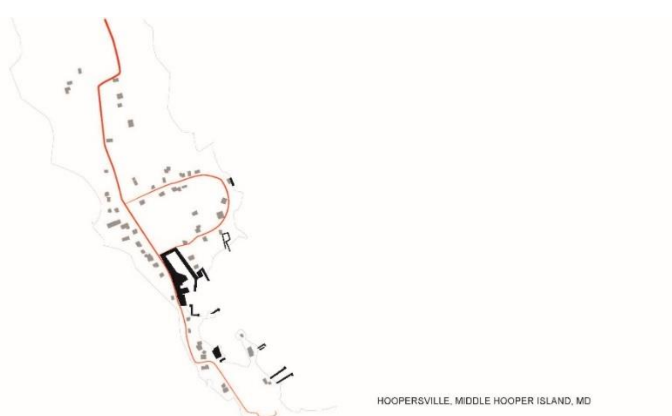

Figure 15: Centralized Marina at Hoopersville, MD – Image by Author

In some towns, centralized marinas have developed. The scale of the marina varies, but for commercial harvesting, the average size varies from anywhere between 20 and 100 slips. Centralized marinas are more efficient for the trade, and allow the packing and processing facilities (and restaurants) to be located directly adjacent to harvest offloading facilities.

General Characteristics of pleasure towns:

Pleasure towns, in contrast, arose in the Late 1800’s to 1900’s On the shore of the Chesapeake bay. As the middle class became more affluent, The Chesapeake bay became a lucrative opportunity for people to vacation in the region. These towns are often planned communities, such is in the cases of Tolchester Beach, and Colonial Beach, and are situated within a short distance of larger metropolises.

Pleasure towns usually include some combination of a beach, a marina that caters to recreational boaters, a boardwalk, and recreation facilities. Beyond the hospitality sector, there is not much commercial development, nor are there many year round residences. As a result, these towns are more prone to failure, especially when they are designed entirely around the hospitality industry.

In the case of Tolchester Beach, for instance, the town existed as a weekend getaway for affluent residents of Baltimore. People travelled to the town by ferry, and for a period of town it was a very successful resort, with a large marina and amusement park. Since there was no diversification of livelihood, the town failed almost instantly when the conditions that created it changed. In 1952, the Chesapeake Bay Bridge was built.[42] After the bridge was built, there was easier access for tourists

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[42] CBBT.com

to travel to the eastern shore and ocean beaches by car, and the ferries that had previously crossed the bay stopped running. The town began to fail, and the amusement park closed shortly after this, in 1962[43]. This lack of diversification of commercial activity illustrates how prone to failure these pleasure towns are.

Hybridization of working and pleasure towns:

In many cases, there is a history of hybridization of towns. Commonly, working towns become pleasure towns over time, for a multitude of reasons.
As fisheries fail, for example, towns adapt to become more heavily recreational in nature. This can be seen in Rock Hall, Maryland. Rock Hall was a town that historically was a working town, with a focus on oystering.[44] As the Upper Eastern shore around Rock Hall became environmentally depleted, the oyster fisheries and other fisheries began to fail. Rock Hall was situated near Philadelphia and Baltimore, and became a good location for recreational boaters to migrate to. One industry began to replace the other. Now, Rock Hall is the site of many high class marinas. There is still a commercial fishing presence in Rock Hall, but it is muted and only as large as the region can support. Rock Hall exists as a town that was able to successfully balance recreational and commercial fishing. This is not always the case. With recreational marinas comes the threat of gentrification, where slip prices rise, and the value of homes rises. This will be discussed further.

This distinction of typologies is important to make. There is a difference in the culture of the weekend 'pleasure towns', which are populated mainly by

[43] Maryland Historic Trust
[44] Blackistone, Dancing with the Tide, PP

noncommercial and recreational residents who live elsewhere, and in the ‘historic’ character of the working town, which is populated by watermen, and industries and support services designed to perpetuate that way of life. There is a pattern of gentrification that is evident in working towns that are geographically closer to large cities, where city dwellers purchase houses and marina slips, and displace working watermen. This can be seen in towns such as Havre De Grace, Maryland, and Rock Hall, MD. Working towns become Pleasure towns as the population of the region expands, and perhaps dissolves the waterman or tidewater culture of the area.

Pattern of threats to tidewater town (gentrification, working/pleasure towns)– While there are both geographical and environmental threats to the tidewater town and lifestyle, this chapter illustrates that there is also a pattern of threats to this way of life that exists outside of the general environmental concerns (which also need to be accounted for.) Much can be done on the engineering scale to protect and regenerate landscapes, but what is being protected if the underlying conditions that created the culture are missing? Any solution that proposes regenerating the environment must also explore regeneration of the conditions that created a culture. Gentrification, and loss of history are some of these concerns.

The formation and history of these towns may be based on location, but it is not possible to have a town without people. It also is necessary to understand the culture of these towns in order to understand why they grow, live, and die. The following chapter will discuss and explore what exactly this ‘tidewater culture’ is, and how it is manifested through people, and through their architecture.

Living on the Edge: The Waterman and Tidewater Identity

Figure 16: Chesapeake Bay Watermen

How can this tidewater and waterman identity be extracted? The tidewater identity, as previously mentioned, is one with a storied history. It has been documented and analyzed, most notably in works of fiction, and in the form of memoirs. It is possible to extract this waterman identity from these works. Further analysis can be made by interviewing and speaking with active watermen.

This section will explore the Waterman identity, and how it can be used to inform one about some of the culture of a place – what were the conditions that generated this culture, and what were the artifacts of those conditions?

The three pieces of literature to be analyzed were selected as they speak about the archetypical waterman. Some of These pieces include James Micheners Chesapeake, Tawes “God, Men, salt water, and the eastern shore”, and Blackistones “Dancing with the tide.” There is considerable overlap in these pieces, but common themes arise.

Characteristics of the Waterman Identity

Freedom and Independence:

To some, the watermen are revered as outriders, and exist as one of the few remaining hunter-gatherer lifestyle in the modern world. The identity of the waterman is similar to the identity of the cowboy. A lone ranger, on his own, making a living off of the land.

The individual waterman often pilots his own boat, and is the sole person in charge of where, when and what they are going to harvest.[45] There is a level of freedom in the waterman culture, which is not present in other industries.

Freedom of choice and independence are some of the backbone characteristics of this identity. Another major characteristic is the notion of ownership of the environment. This often leads to a sense of responsibility and perhaps stewardship. Within individual productive fishing areas, there may be a dozen separate boats harvesting the same acre. Each individual waterman knows what the catch limits of the harvest are, and what the appropriate harvesting zones might be.

Anachronistic Nature:

Further, the waterman identity is a bit anachronistic. In an era of industrialization, the State of Maryland has determined that some of the best methods of preservation might be to limit the technological methods of harvest. The Chesapeake Bay has the only remaining fishery that is harvested primarily by sail, the skipjack fleet is restricted to oystering under sail power for 5 days of the week.[46]

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[45] Dancing with the Tide, pp 42
[46] Harp, Waters Way: Life Along the Chesapeake

There are limits to the locations and volume of oyster harvesting that may be done by method, hand tonging and diving for oysters have a different catch limit than dredging and machine tonging. In this author's opinion, these anachronistic methods of harvesting are a reminder of the age of the tradition more than an effective method of culling a harvest.

Figure 17: Chesapeake Bay Skipjack

An additional side effect of the difficulty of becoming a water (It's essentially impossible to get a skipjack oystering license or a commercial crabbing license) means that the tradition is passed down into families. Smith Island's Ewell and Tylerton are small, tight knit communities that essentially survive by passing down the waterman tradition from father to son. Oyster Medallions and Crab Licenses are prized possessions, and rarely come for sale on the open market.[47]

[47] Blackistone, Dancing with the Tide

Like the licenses, the physical tools of the trade and are also a barrier to entering this culture. Techniques like hand tonging and sail powered dredging are difficult and must be taught, even the maintenance of a 100 year old sailboat is complex enough to require a lifetime of apprenticeship. The obscurity of the trade again creates the 'mystique' of the waterman identity.

Hand Crafted:

Another aspect of the waterman culture that is enviable is the necessity for do-it-yourself solutions. The Oyster Skipjack is an entirely home grown solution, and most of the watercraft used in the bay were built in the bay. There are no standards of construction for a skipjack, many were pieced together by the watermen in their backyards. Since so many of the boats and tools and equipment are passed down waterman to apprentice, there is a large amount of work that must be done to maintain these artifacts.

Even the tactics of harvesting and fishing are hand crafted solutions. Waterman are constantly trying to improve their methods, and are constantly innovating new techniques and trying out new ideas to get a better catch.[48] Again, these techniques get passed down just as often as the material, and each individual waterman might have an entirely different skillset and notion of 'best practices.' There is no manual for watermen.

Resilience:

Finally, the notion of resilience in the waterman culture is something to be admired. As their environment is threatened and their means of sustaining themselves

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[48] Blackistone, Dancing with the Tide

degrades, the watermen manage to carry on. Watermen used to be defined by the type of harvesting they did, year round careers could be made out of just being a crabber, an oysterman, a fisherman. But the current state of the bay and its harvest regulations imply that the modern waterman must be versed in every fishery, in order to make their living.[49]

Even before reducing catch sizes started to push the watermen to be more multidisciplinary and maintain year round schedules, variable catches have forced the watermen to be flexible as well. Harvest scales are naturally variable, and an overall catch for the year can vary by millions of pounds. For example, the harvest scale of oysters in the Chesapeake's 1998 season was 2.5 million pounds, but only around 800000 lbs in the 1999 season.[50] Watermen must thus always be prepared for change.

This also applies to the watermen when it comes to protecting their heritage. A large portion of the 'purest' waterman culture is extant on the remaining Chesapeake Bay island communities, on Tangier and Smith Islands, the existence of these communities is not threatened by declining harvests but by rising sea levels. Again, there is a pattern of resilience. These communities may be lost to rising sea levels in as little as 50 years.[51] Still, the watermen continue to remain. There are talks of shoring up the island with help of the army corps of engineers, but until them, Smith Islanders are observed raising their homes with increasingly high CMU foundations. The waterman culture is one that fights to survive.

[49] Blackistone, pp 90
[50] Blackistone, pp 67
[51] http://marylandreporter.com/2013/07/29/rising-seas-2-former-seafood-capital-crisfield-struggles-to-survive/

Food Culture in the Chesapeake

In the entire Chesapeake Tidewater, the diversity and unique aspects of the local food sources have generated a very unique palate of food. Today, the region is known for its diversity of seafood choices, and local specialties that are a regional tourist draw.[52] To any visitor or local to the Tidewater Region, it is clearly evident that food culture constitutes a sizeable portion of what it means to be a "Marylander," and what it means to be a member of this Chesapeake Culture.

Maryland can trace its food heritage to the cuisine of Colonial settlements, who borrowed food traditions from the Algonquin Native Americans that inhabited the Bay Region prior to the colonists.[53] While early food culture was more focused on sustenance (Jamestown's Success is partially attributed to the bountiful oyster bars that were easily harvestable in times of crop failure[54]), the Maryland diet's changed over time into a diverse palate of food as settlements became more established. The diversity of food and the regional differences, which often vary even at the County by county level, has created a robust regional cuisine scene, and an endless variety of dishes to sample.

The Maryland Blue Crab

Callinectes sapidus, or the Atlantic Blue Crab (Regionally known as the Chesapeake Blue Crab) Is the flagship seafood of the State of Maryland. When people think of Maryland, often the next thing they think of is the Blue Crab.

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[52] Seafood Lovers Guide to the Chesapeake Bay
[53] Seafood Lovers Guide to the Chesapeake Bay
[54] Chesapeake Oysters

[redacted]

Figure 18: Chesapeake Blue Crab[55]

The blue crab has always been considered a 'specialty' food. While most types of seafood can be frozen and transported, crabs must be cooked immediately for them not to spoil. Thus, blue crab consumption had remained a local tradition until refrigerated transport allowed suppliers to move crab more freely.[56]

The Ritual of the Crab Feast:

Among all of the food based traditions of the tidewater region, the ritual of the crab feast is the most bizzare to outsiders. However, the crab feast is considered a rite of passage to any Maryland Resident.

[55] Courtesy of the Children's Museum of Indianapolis
[56] Kennedy & Cronin – The Blue Crab: Callinectes Sapidus, pp 656

Figure 19: Marylanders at a Crab Feast - Image By Author

Unlike other fine dining traditions, or even oyster consumption (another important regional seafood), consumption of a crab cannot be refined and cleaned up. The process of cooking eating crab is incredibly 'barbaric' in nature.[57] The entire ordeal is messy and primal, as the most effective process of consuming a crab still consists of pulling the legs off to get at the leg meat, then flipping the crab over and prying off the shell, and pounding it apart with a hammer to enable oneself to pick out the crabmeat with ones fingers.

The crab feast hearkens back to a communal gathering and eating environment, and perhaps this is why food culture in the Maryland area is so strong. Consumption is still communal, and recurring gathering events may have fostered strong community building. Crabs are typically dumped onto a table covered in

[57] Seafood Lovers Guide to the Chesapeake Bay

newspaper, and consumption becomes a free for all. The majority of the game involves teaching the nonnative to eat crab.

The cooking process of crab is not as variable as other meats, and is as barbaric as the consumption process While there are a variety of methods of preparing crab meat, (such as crab cakes), crab must all be cooked the same way. Crabs are cooked alive. A pot of boiling water is prepared, and they are unceremoniously dumped into this pot along with old bay, a can of beer, or other seasonings, and cooked to a boil 'until the shells turn orange.' If the crab meat is destined for a feast, this is all that needs to be done to the crabs besides dousing them in seasoning. If it is being prepared otherwise, the meat still typically needs to be picked out by hand. There is no machine that can effectively pick all of the the meat out of a crab, and packing houses still employ people to hand pick the best pieces of meat.[58] Again, it can be speculated that part of the allure of crab is that one knows exactly where their food comes from, and that there is still a tactile process of preparation and consumption.

The Chesapeake Oyster

Second in importance to the Chesapeake Bay diet is the Virginia Oyster, or *Crassostrea virginica.* The Oyster has been a staple of the Chesapeake Diet since the earliest efforts of colonization in the region.

[58] Chesapeake Bay Maritime Museum - Exhibits

[redacted]

Figure 20: The Virginia Oyster[59]

Oysters exist as a contradiction. Visually, they are one of the most unappealing foods that exist. Unlike clams or mussels, which have a regular form and a symmetrical pattern of growth, oysters could be mistaken for rocks, with their rough irregular shape and growth. Cracking open an oyster reveals a slimy interior, with a metallic meaty center, one wonders who decided to be the pioneer eating them in the first place. The taste of an oyster is a very rich one that can be best described as briny, or 'acquired.'

Oysters are prepared in a number of manners, from steamed, to roasted, to fried, but the traditional method of consumption is to pluck them out of their shell raw, and alive. As is the case with all seafood, the fresher, the better.

The ritual of the oyster raw bar:

[59] http://www.coastalvirginiamag.com/

Purists of oyster consumption consider the oyster raw bar, or ‘oyster palace’ the epitome of oyster culture. The oyster raw bar is essentially of the same typology of restaurant that a wine bar might be, like at a wine bar, various breeds and species of oyster are sampled as a delicacy. The flavor of an oyster varies greatly based on where it was harvested, as the microclimate and the water conditions are the primary components of the oysters’ flavor. Oysters absorb their surroundings, and in the Chesapeake Bay, the Virginia oysters taste varies greatly, since the salinity, water bottom, and environmental quality, are components of the overall flavor of the oyster, is so variable by geographic location. This flavor profile, inherent to growing conditions the oyster, is defined as the *merroir* of the oyster.[60]

Figure 21: An Oyster Raw Bar

The raw bar is the location where such a sampling of *merroir* takes place. The oyster raw bar exists as a place to compare and contrast differing oysters. While the

[60] Chesapeake Oysters

modern raw bar samples oyster at a global scale, the historical raw bars in the region sampled Chesapeake varieties.

While not a restaurant typology that is completely unique to the tidewater region, the raw bar, with its roots in Victorian oyster houses, is currently resurging in popularity, as food culture, and sustainable food comes more into vogue. Oyster houses used to be prevalent across the United States, but their popularity plummeted as the oyster population crashed.[61] Oysters have moved from a staple food to a delicacy food, and this has elevated the role of the oyster house into the realms of the "foodies." Since it is much easier to bolster a cultural identity that is already manifested physically then it is to recreate something that no longer exists, tapping into this subculture and raw bar heritage may be a method of increasing a sense of ownership of the Chesapeake (oyster), and the stewardship and responsibility that comes with that mindset.

Historically, the Oyster is perhaps more important than the crab in terms of the settlement and development of the Chesapeake Tidewater Region. Jamestown, the earliest settlement in this part of America, scraped out a survival by harvesting the endless oyster bars that surrounded the town.[62] Jamestown's placement was rather strategic, as the settlers who travelled to Jamestown were not fit for farming. Multiple seasons of crops failed and Jamestown had multiple run ins with the native American population, who were not as receptive to their arrival as they were in other parts of the Eastern United States. When crops failed and hunting failed, the oysters remained.

[61] Chesapeake Oysters
[62] Chesapeake Oysters

They could be harvested and eaten raw. Without the oysters, Jamestown may well have failed.

Oyster culture was also the foundation of industrialization in Maryland. Both Baltimore and Crisfield, (once rivalling Baltimore in size and prosperity) were founded on Oysters. The easy harvest of oysters and their relative bounty led to quick growth and adoption of the railroad in both of these towns, as what became a staple food was transported north to Philadelphia and New York, regions that also depleted their natural supply of oysters, by rail.[63]

Whether or not the oyster heritage of the Chesapeake exists as a memory of what sustained the Virginia and Maryland colonies, or as a holdover from the industrialization and exploitation of the oyster fisheries of the late 1800s, the Virginia oyster remains a staple of the food culture of the region.

Regional Diets: Bay to Table

The regional diet is also notable for the sense of connection to the environment that is created. Many of the 'best' crab houses and oyster raw bars and seafood restaurants are often on the shore line outside of town, in a place where the connection to the environment seems more real. The idyllic seafood restaurant in Maryland is often described as 'rustic'[64], outside of town, on the side of a creek or estuary.

[63] Chesapeake Oysters
[64] Seafood Lovers Guide to the Chesapeake Bay

Figure 22: Seafood House in Ewell, Maryland. Image by Author

Even in the home, this idea of Maryland Cuisine as a cuisine that is closely intertwined with the environment exists. The process of acquiring seafood in Maryland is still one that involves 'knowing a guy' who sells seafood out of his house, and this person is often the waterman who harvested it that same morning. A proper Marylander will never buy seafood from a grocer. Again, this creates the same connection to the environment.

Figure 23: Roadside Crab Sales, Havre De Grace. Image by Author

It is arguable that the process of acquisition of seafood is one of the primary cornerstones of the mindset of stewardship in the Chesapeake Bay. Rally cries of “save the bay,” made popular by the Chesapeake Bay foundation,[65] are echoed in the minds of Marylanders who drive out to these idyllic landscapes to get their food. The tourist whose only interaction with the bay is as a water obstacle cares less for the well-being of the environment. The tourist who understands that the health of the fisheries, the quality of the food, and the quality of the environment are interrelated will go to greater extents to “save the bay.”

This shift in mindset is already beginning to occur in some places. The term “Bay to Table” is used in some locations to describe the quality of the food. Bay to Table a concept similar to the notion of “Farm to Table” which is a manner of acquiring food that is cognizant with the entire production process. Where farm to table is concerned with the quality and location of the farm where a particular crop might be harvested, and the process of transport and processing that led to the consumers table, Bay to Table is concerned with the quality and location of the harvest. Farm to table might prioritize an organic farm, for instance, and bay to table might be concerned with sourcing seafood from a sustainable fishery.

Perhaps the most important piece of information extracted from this analysis of culture is the fact that there is still a desire to be a piece of this culture. As the watermen become more threatened by environmental conditions that remove their

[65] Chesapeake Oysters

livelihood and cultural conditions onshore that price them out of their communities, there is still a subset of people that are drawn to the water, who are drawn to the food culture of the region, and who build within the framework of tidewater architecture. With this in mind, it is possible to design for this reality.

If this strength of culture has created some sense of stewardship, how can it be utilized as a method to foster regeneration?

Chapter 4: Aquaculture

What is Aquaculture?

The Food and Agriculture Organization of the United Nations (FAO) defines aquaculture as such: "*Aquaculture is the farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants*."[66] Outside of the United States, aquaculture is a more widespread practice, and in regions with a very long history of habitation, fish farming and aquaculture using simpler methods (including extensive aquaculture tactics) has been used to great effect to create naturally sustainable fisheries.

The FAO considers rural aquaculture an important methodology that can be used to increase the welfare of small scale household operations. [67] Notably, this type of logic could be extended towards rural Chesapeake Tidewater regions, where an overreliance on harvesting of the fisheries has led to the same type of environmental conditions that threaten small scale households and communities in less affluent communities. [68]

This document proposes that a level of aquaculture is needed in order to sustain the commercial fisheries of the Chesapeake Bay. While these types of operations are being explored in the Chesapeake, in places such as Hoopers Island Aquaculture, The Choptank Oyster Company, and Horn Point Oyster Hatchery, among others, there is not enough of a large scale master plan in place that can

[67] FAO: http://www.fao.org/docrep/003/x6941e/x6941e04.htm
[68] FAO: http://www.fao.org/docrep/003/x6941e/x6941e04.htm

guarantee the effectiveness of these isolated operations. If aquaculture is to be practiced (and practiced in a sustainable manner) in the Chesapeake, there needs to be a framework scale organization of these networks of farms. Aquaculture in the Chesapeake needs to move away from experimentation and small scale operations, and needs to move towards working at a scale that can repair an environment that is near collapse.

Types of Aquaculture

Extensive vs Intensive Aquaculture

Broadly, aquaculture can be broken into two categories of methodology. These consist of extensive aquaculture, and intensive aquaculture. In an extensive aquaculture operation, the habitat and production of product is controlled semi-naturally. In an extensive system, there are lower levels of intervention in the day to day operations of the farm, as feeding and other activities are based on the natural carrying capacity of the environment. Success of an extensive aquaculture system relies on the natural photosynthetic processes of the environment.

The benefits of an extensive aquaculture system can be found when examining the upfront cost of such a system. The costs to build an extensive system are based on the price per square foot of the land needed to farm. There is no recurring cost of food or nutrients that need to be added to the system, and there is also no large start-up cost necessary to create recirculating systems that are necessary in intensive aquaculture systems, to be described later.

In an extensive aquaculture system, the drawbacks are related to the scale of the operation. Smaller scale ponds are naturally limited in potential output as there will be a smaller base of photosynthetically created nutrients.[69] Since extensive systems are based on field area, raising the area of water needed to produce higher levels of output may not be possible based on local land value, or space available. Output can be raised by adding nutrients externally, but the operation runs the risk of a higher recurring cost of operation.

Another drawback of the extensive aquaculture system is the risk of algae blooms that can potentially kill an entire pond. With an extensive system based on a monoculture of crop, algae blooms can exponentially grow and starve a system of food and nutrients, and as algae subsequently dies, the resulting decaying biomass can pollute a system to the point where large die offs of harvest is imminent.

Intensive aquaculture systems, on the other hand, are based on the implementation of a series of artificial systems that mimic a natural habitat conducive to the growth of the crop. Intensive aquaculture relies on artificial water recirculation and aeration systems, large scale water habitats to grow marine crop, and an artificial nutrient and feeding schedule. With a careful monitoring of environmental conditions, it is possible to increase the output of aquaculture by an order of magnitude. [70]

Intensive aquaculture systems generally take up less land area than extensive systems, as the structures required to create these systems can be fairly compact. Overall, the cost per pound of crop (fish) is higher than in an extensive system. While

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[69] https://en.wikipedia.org/wiki/Fish_farming
[70] https://en.wikipedia.org/wiki/Inland_saline_aquaculture

intensive is a more efficient practice, the recurring cost of food and protein needed to run the system moves the overall cost to a higher level.

A drawback of the intensive method is that it is potentially much more stressful on the environment. While intensive aquaculture can maximize efficiency of labor and minimize the amount of land impacted due to the smaller footprints of the operations, Intensive aquaculture operations use around 1,000,000 Gallons of water per acre per year, which creates a heavy environmental and infrastructural burden.

Onshore vs. Offshore Aquaculture

Aquaculture is broken into two major form based categories, which are land based operations (onshore aquaculture) and water based operations (offshore aquaculture.)[71]

Onshore Systems:

Fry Farming and Fish Hatcheries:

Fish farming and Hatcheries are interrelated, but differ in their application. “Classic Fry Farming” is the process of hatching fish in an onshore facility, and then releasing them as juvenile fish into uncontrolled ecosystems, where they are allowed to mature naturally and be harvested through conventional means. Classic fry farming occurs in long shallow tanks that are generally connected to a local stream, the stream is allowed to ‘flow through’ the operation. Fry Farming is more common in freshwater ecosystems, it is easier to control the growth and simpler to implement.

[71] https://www.daf.qld.gov.au/fisheries/aquaculture/overview/types

Fish Hatcheries are similar to Fry Farms. [72] Unlike conventional fry farms, fish hatcheries are not location bound to a nearby stream. They are either freshwater or saltwater operations, and are used for the germination of a wide variety of fish. Fish hatcheries tend to grow fish to a higher level of maturity then fry farms, and from the hatchery, juvenile fish move into fish farms and pond systems where they grow to maturity in captivity until they are harvested.

Hatcheries can either exist as an independent entity, or can be tied to a nearby operation. As such, their location and design is highly flexible.

Pond Farming:

Illustration 7: A typical aquaculture pond farm

In Pond Farming, ponds are built onshore for the purpose of extensive or semi-intensive culture of marine crop. Pond farming can be utilized for the production of both fish, mollusks, and shrimp, and application of the pond method to

[72] https://en.wikipedia.org/wiki/Fish_hatchery

other harvestable species is possible. The scale of operations in a pond system is limited by the available land area, as the amount of potential biomass growth is limited by the nutrients available in each pool, but insertion of nutrients into the system (creating a semi intensive system) can boost output.

Ponds are more economically effective in area where land is cheaper and more plentiful. Pond depth is variable, but generally is around 1.5-2.0 meters in depth.[73]

Integrated Recycling Systems

Illustration 8: Integrated Recirculating System Aquaculture.

Integrated recycling systems are one of the best practices in terms of aquaculture in terms of efficiency. A typical integrated recycling system is a series of tanks, held within greenhouses. The marine culture is given a food source and a nutrient supplement; and the cultures waste is circulated out of the culture tank, and into a secondary tank that consists of a biological hydroponic bed system, which

[73] https://www.daf.qld.gov.au/fisheries/aquaculture/overview/types/ponds

converts ammonia and other waste products into nitrates. The hydroponic beds can also be utilized to grow crops, and this secondary crop can also be sold for profit.

Integrated recycling systems are the most efficient method of aquaculture when grading efficiency to biomass production, but these types of large scale systems have a larger environmental impact. These systems are semi closed loop systems, and typically have no connection to the environment. The positive feedback loop that nitrate fixing crops might have is spent within the integrated recycling system, so there is no potential to 'heal' the outside environment. Further, integrated recycling systems discharge waste that is difficult (but not insurmountable) to treat.

An additional benefit of such a system is the fact that they are not site specific, The closed nature of them implies that they could even be located inland if need be.[74]

Recirculating Systems

A recirculating aquaculture system is typically indoors, and tank based. It is similar in nature to the integrated recycling system, except for the fact that recirculating systems are completely closed loop.

They are similar to a fish tank environment, but operate at a larger scale. Unlike the integrated recycling system, a recirculation system retains all of the inputs, and water and nutrients are recycled back into the tanks after filtration. Solids, ammonia, and dissolved Carbon Dioxide are removed from the water, and the water is reoxygenated before it is placed back into the tank environment. These operate with a lower waste output, and are one of the more environmentally friendly methods of

[74] Freshwater Aquaculture: A Handbook for Small Scale Fish Culture in North America, Mclarney

onshore aquaculture.[75]

Offshore Systems:

Offshore aquaculture systems are generally of a larger scale then onshore systems. They can be based in estuarine or riverine environments, and also can be based entirely offshore in the open ocean. Offshore systems generally tend to vary more in scale and are less tied to location, with some offshore systems being entirely moveable.

Sea Ranching:

Sea ranching is a method of cultivation where the animals to be cultivated are grown onshore, and as juveniles (generally spat) are moved to the natural environment after reaching a level of maturity. The animals are then allowed to occupy the uncontrolled environment, and when they reach a harvestable size, they are recaptured. This is a viable method for animals that tend to not move very far from where they are placed, using organisms such as oysters, clams, and scallops. During this interim period between placement and harvesting, there is not much input into the system that is required of the farmer, as long as the environmental conditions are favorable, the crop essentially tends itself.

A potential issue that might arise from a sea ranching practice is that in order to be effective, sea ranching relies on a leased bottom, or private ownership of the seabed.[76]

Racks:

[75] http://www.blueridgeaquaculture.com/recirculatingaquaculture.cfm
[76] https://www.daf.qld.gov.au/fisheries/aquaculture/overview/types/sea-ranching

Rack aquaculture is a method of Oyster culturing that involves the use of suspended plastic or metal mesh bags that each hold a number of oysters. These racks are typically placed in intertidal waters, and are suspended above the sea floor. They can be suspended through the use of adjustable cables, or through the use of buoyant floats. The use of adjustable lines allows for the placement of the racks to vary vertically within the water table, which can be beneficial towards controlling culture growth. A benefit of this system is the low environmental impact from its development. The only subsurface disturbance that is created by a rack aquaculture operation is through the posts that line the system, and since the racks float within the water column, normal animal and plant activity on the sea bottom can still occur with minimal disturbance.[77]

Rack and Line:

Rack and Line aquaculture, also known as Surface or Subsurface aquaculture, is the process of suspending panel structures that are filled with filter feeding animals within the water column. The difference between a surface and subsurface system is marked by the specific placement of the tie line, a tie line on the water surface is considered a surface rack and line system, and one that sits under the surface is considered a subsurface system.

This methodology is essentially using the same process of growth that traditional rack systems use. Separate racks are hung vertically in the water, and are tied together with a cable that is pulled taut via anchors and buoys. This allows for the entire system to be moved if needed, and also allows for separate racks to be placed at

[77] https://www.daf.qld.gov.au/fisheries/aquaculture/overview/types/racks

greater distances apart from each other. Like in Rack aquaculture, there is an inherent benefit in this methodology as there is little disturbance of the sea floor. Additionally, the greater spacing that is possible through a rack and line system allows for higher levels of light to filter into the surrounding environment.[78]

Cage System:

Figure 24: Cage System Aquaculture

Cage Aquaculture Systems are a method of intensive aquaculture of fish. Generally, there are large scale circular cages that can accommodate many members of the same species. Cage design and scale is based on the types of fish being harvested. Cages are typically made of nylon or plastic mesh, and suspended on the water surface using buoys or a rigid frame system, but other materials and methods can be used. In cage aquaculture, fish are allowed to mature and live entirely within the cages, and nutrients, food, antibiotics, and such can be applied to the fish within

[78] https://www.daf.qld.gov.au/fisheries/aquaculture/overview/types/surface-lines

the cage.

There is a considerable environmental impact that comes with an improperly designed cage system. As there is a large concentration of biomass in one specific area, there can be quite a bit of polluted outflow from the cages. A well-managed system can mitigate the risk of adverse environmental impact, but even then, there is still the concern of fish escape.[79]

Applicability to Estuarine Environments

Not all of these methods are applicable in estuarine environments such as the Chesapeake Bay. Mariculture systems (systems that are further out to sea) are more difficult to adapt to estuarine environments where water depth and scale of spaces required are more of a concern. Historic practices and current methods of aquaculture in estuarine environments needs to be understood to effectively select a methodology that will be appropriate for the Chesapeake Bay Tidewater. It is to be assumed that the combination of tactics used will be site specific, and any large scale operation will need a level of onsite, and offsite aquaculture.

[79] https://www.daf.qld.gov.au/fisheries/aquaculture/overview/types/sea-cages

Case Study: Veta La Palma, Spain

Figure 25: Aerial Image of Veta La Palma, Spain[80]

Veta La Palma is an example of such a large scale extensive aquaculture operation which is notable for its effective integration of land preservation, aquaculture operations, and rice cultivation. The Veta La Palma estate encompasses 28,000 acres of estuarine environment, which integrates land established as national park areas, the aquaculture estate, and buffer regions.[81] As a flagship project of sustainability, Veta La Palma takes account of the importance of balancing both the ecosystem and economies at a regional scale.

[80] https://thepiscivore.files.wordpress.com/2015/06/936c6-veta-aerea.jpg?w=630&h=261
[81] Biodiversity-friendly aquaculture on the Veta la Palma Estate, Spain

Figure 26: Map of Veta La Palma, Spain[82]

The operation is considered a "close to nature extensive aquaculture" system. Wetlands are combined with extensive aquaculture, which takes the form of land based ponds that vary in scale, typically they are sized around 100 acres each. The fish ponds (the bulk of the aquaculture operations) alone encompass 8000 acres of land area, and is divided into a series of 45 interconnected ponds. These ponds then filter into irrigation channels and drainage paths, which filter the outflowing water into the local river system.

Veta La Palma reduces the adverse impact on the environment by reducing the biomass load within the individual ponds. The fish are fed mainly through 'wild catch,' which includes algae and shrimp that grow naturally in the ponds. This naturally limits the maximum density of fish in the ponds to about 4kg of biomass

[82] http://legacy.ecoagriculture.org/~ecoagric/images/image.php?imageID=492

(fish) per 1 cubic meter of water. In contrast, intensive aquaculture operations operate at much higher densities. [83]

The estate is valuable to understand as a precedent for a potential solution in the Chesapeake. The large scale of the operation has the ability to affect many pieces of community and ecology. Veta La Palma also operates as a marsh area restoration and wild bird sanctuary. While they lose a percentage of harvest to waterfowl consuming potential harvest, the ecological benefits outweigh the costs of operations. Ecological benefits may also include the increase of biodiversity in the national park and sanctuary, and economic benefits are created by the Spanish government allowing such a scale of operation within a national park.

Further, it integrates local communities in the operations of the estate. The aquaculture portions of Veta La Palma are maintained by about 100 local farmers from the nearby town. The operation is proven in its ability to create a benefit to local economies while also promoting sustainability. [84]

[83] Biodiversity-friendly aquaculture on the Veta la Palma Estate, Spain
[84] Biodiversity-friendly aquaculture on the Veta la Palma Estate, Spain

Figure 27: Fish Harvesting at Veta La Palma, Spain[85]

Precedent Analysis:

Large Scale Chesapeake Aquaculture: Horn Point Oyster Hatchery

Horn Point Oyster Hatchery is the largest scale oyster aquaculture operation in the state of Maryland, and perhaps the largest on the east coast. While it is primarily a state funded research institution and not a commercial for profit enterprise, it is important to understand how large scale aquaculture systems can work. At Horn Point, oysters are grown from in an intensive aquaculture system, before they are released in the environment via barge, in effort to facilitate large scale habitat restoration. Many of these oysters are released in sanctuary areas, but some are released into public shell fishing areas – essentially seeding these zones for commercial watermen to harvest within.

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[85] FAO.org

Horn Point is broken into two separate large scale components – an indoor facility, and an outdoor facility on an adjacent dock. The plan diagram below illustrates this adjacency (locations not to scale)

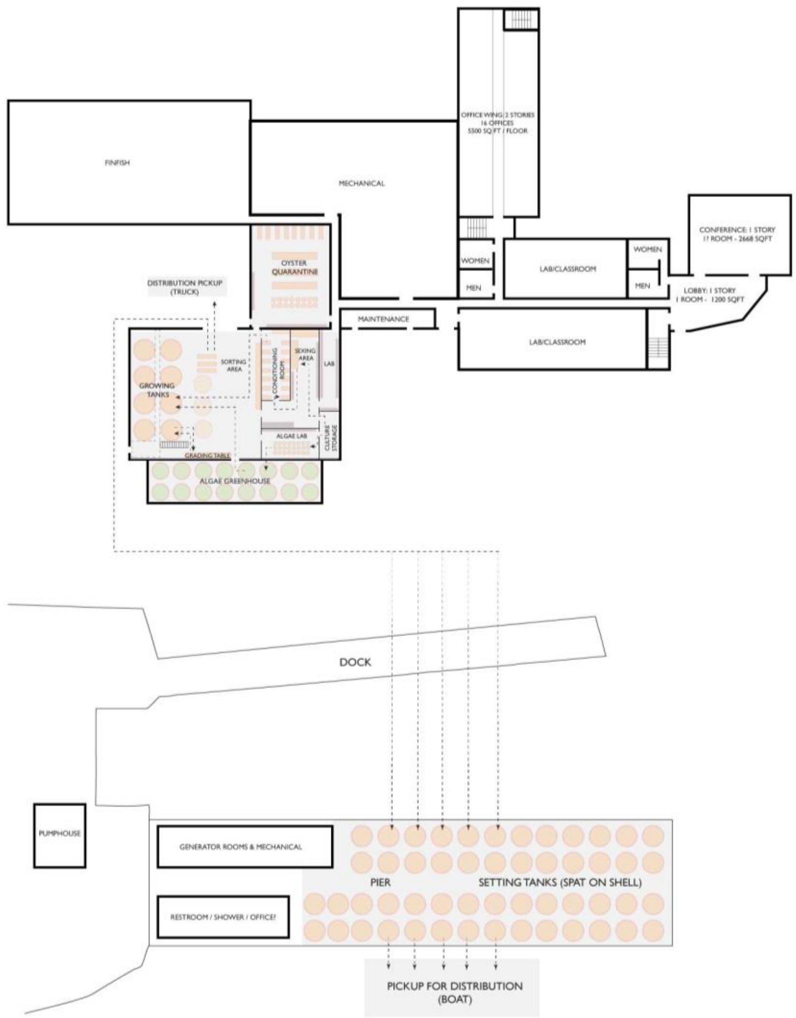

Illustration 9: Horn point Oyster Hatchery Plan Diagram. Illustration by Author

The entire oyster rearing process occurs inside the hatchery building. Inside, oysters first go from a stock room (where live oysters are stored over the winter for future seasons), to the Broodstock Conditioning Labs. Oyster spawning is governed completely by ambient water temperature, so the conditioning labs consist of a series of tables where groups of broodstock oysters (Typically healthy oysters selected for spawning) are conditioned with higher temperature water, in order to convince the oysters that it is spawning season. A number of separate tables can be used to both control when in the season the particular broodstock will spawn, and also to raise the scale of the volume of total oyster that will spawn.

Illustration 10: Conditioning Tables – Image by Author.

After the oysters are convinced that it is spawning season, they are moved from the conditioning tanks to the sexing tables. The sexing tables are at a smaller scale than the conditioning tanks, as smaller numbers of oysters are needed at any one time for fertilization. Fertile male and female oysters are set out on a grid arrangement on separate tables, and after they spawn, their gametes are moved into separate storage containers until they are combined for fertilization.

Illustration 11: Sexing Table at Horn Point – Image by Author

After the gametes are fertilized, fertilized eggs are transferred to the growing tanks. There are 8 growing tanks at horn point, they can accommodate a weeks output of oyster spat growing concurrently. Oyster spat are allowed to grow in the tanks for 2-3 weeks, and are fed a mixed diet of algae (grown on site in an algae greenhouse at the facility) and conditioned water to best facilitate robust growth. After this 2-3 week growing period, the oysters have developed to a point where they will be ready to attach to a substrate. They need to be removed from the growing tanks at this point, or they will attach to the growing tanks themselves.

Illustration 12: Growing Tanks – Image by Author

The final indoor programmatic component of the oyster hatchery is the algae greenhouse. Algae is grown on site, simply because it is more economical to produce their own algae at the scales they need. Much like the broodstock lab, algae stock is kept refrigerated over the winter, and fiberglass algae tanks in the greenhouse are inoculated with algae stock. 4 species of algae are grown, and the algae is fed conditioned water, and fertilizer, and is consumed by the oyster spat in the growing tanks directly after being produced.

Figure 28: Algae Greenhouse at Horn Point - Image by Author

After the oyster larvae is removed from the growing tanks at Horn Point, it is moved to the setting tanks. The setting tanks are situated at the water's edge. Oyster larvae are placed in the tanks, which are filled with an oyster shell substrate, and are allowed to 'set' on the substrate. After 48 hours the majority of the oysters should be set, and they are fed river water and algae until they are picked up for transport.

Figure 29: Setting tanks at Horn Point – Image by Author

The below image illustrates this program in a diagram format. It shows that a large scale operation has a series of multiple complex processes that lead to the production of oyster spat for a restoration operation. If this was to be applied to an aquaculture installation, the same growth process would be used.

In the program breakdown, it is evident that the algae process and the oyster culture process are the most critical elements of the program – they are interdependent. Any large scale hatchery for aquaculture will also require infrastructure of this scale.

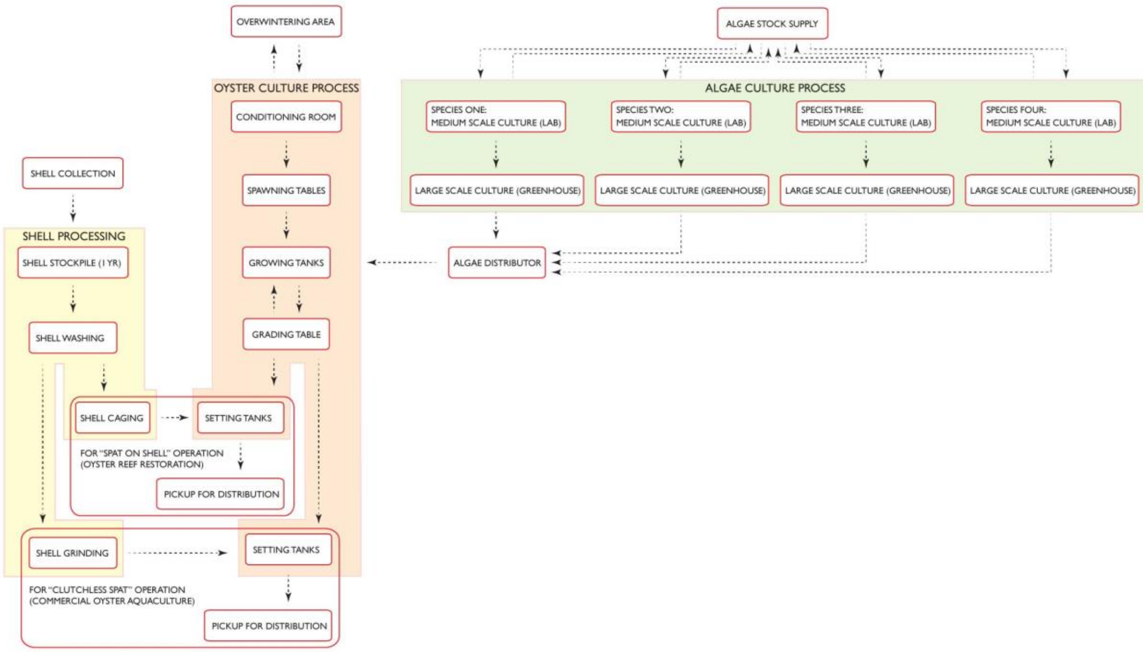

Figure 30: Operations Process Diagram at Horn Point – Image by Author

Figure 31: Program Breakdown at Horn Point – Image by Author

Small Scale Chesapeake Aquaculture: Baltimore Fish Farm

While less established in the Chesapeake Bay Region, small scale onshore aquaculture is becoming more common as the demand for marine biomass increases. One such location where this is being explored (at the educational level) is at the Baltimore Fish Farm in Baltimore, Maryland. The Baltimore Fish Farm is run by the University of Maryland’s Center for Marine Biotechnology.

Illustration 13: Baltimore Fish Farm

Their aquaponics systems, while not dissimilar to Horn Points, take place entirely onshore in warehouses, and utilize an integrated recirculating system. The operation farms Cobia, a high priced Eastern Coast fish. The higher value per fish offsets the high startup costs of the smaller scale aquaculture operation. With the integrated recirculation system in use, they are able to grow Cobia at a greater rate than in traditional fish pens.

The Baltimore Fish Farm considers itself a ‘sustainable, low impact’ operation. It recycles 99% of its water (one percent being lost to evaporation), and there is little adverse impact to the Chesapeake. Further, decomposing waste which is converted into methane is used to offset the energy costs of the project.[86]

While the Baltimore Fish Farm is not operating at the scales that have proven to be commercially viable in other regions of the world, it exists as a possible prototype that can be adapted and used elsewhere in the region, at differing scales.

Aquaculture Trails – Educational/Tourist Aquaculture

A novel use of the scales of aquaculture operations in rural environments that is worth understanding is seen in the manifestation of “Aquaculture Trails” in regions where many aquaculture facilities string along a coastline. These need to be investigated because they speak about the potential of a diversification of the practice of aquaculture itself. In many environments, aquaculture, like other farming, is a necessity for survival. Rural communities practice aquaculture to provide sustenance at the local scale,[87] and large scale aquaculture operations, such as what is seen in Southeast Asia[88] operate to provide resources (including food and feed) for larger regions. The aquaculture trail, in contrast, talks about the potential to build up from just aquaculture for survival, and speaks to the potential to design this experience as a touristic endeavor.

The aquaculture trail, where it is seen, seems to follow closely the typology of the “culinary trail” or “wine trail.” Wine trails and Culinary Trails are fairly common

[86] http://www.worldwatch.org/node/5718
[87] https://en.wikipedia.org/wiki/Fish_farming
[88] India, Japan, etc find a source

in the United States, and is an armature that might be able to branch off from. Culinary and wine trails exist as a form of rural tourism development, it is reasonable to assume that an aquaculture trail can operate in the same manner. They are effective in bringing tourists and guests to rural areas, and perhaps have a side effect of creating a desire to preserve these environments as they exist, in a more 'natural' environment. Increasingly, wineries and wine trails focus on environmental aspects of the experience, with some of these trails becoming 'eco tours', where there is a focus on sustainability of the experience and operation.[89] Adopting the wine trail to aquaculture is potentially a powerful method of generating a sense of stewardship of the environment. When people know where their food comes from, they tend to care more about the quality and health of the environment in which it is from.

While at first glance, aquaculture trails seem to be a fledgling industry, they are becoming more established in the Pacific Southwest. South Australia and New Zealand both have large regions of rural coastline that has been populated by aquaculture and mariculture installations and industries focused on the perpetuation of these facilities. In both cases, every aspect of the aquaculture experience becomes a tourist attraction. In Southern Australia, the Erie Peninsula is home to the South Australia Aquaculture Trail.[90]

These types of aquaculture trails are effective in bringing people to rural environments to experience food culture, and such a trail system, such as the one pictured below, could be implemented in the Chesapeake.

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[90] http://www.australia.com/en/places/sa/sa-aquaculture-trail.html

Figure 32: Map of the South Australia Aquaculture Trail

Chapter 5: Site Analysis and Selection

The Macro Scale Chesapeake

Regional Site Concerns

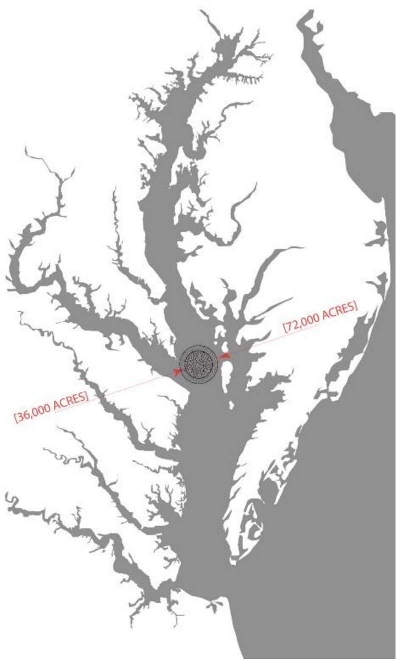
In order to break down some of these regional site concerns into chunks that are more manageable, this thesis is exploring the Chesapeake from the macro scale down. There are of course many regions where intervention is needed, but only a few of these regions are approachable in the context of designed aquaculture. Exploring aquaculture at the regional scale is achieved by examining some of the proposed components necessary for large scale aquaculture. Oyster aquaculture was selected for these studies. These site studies propose that aquaculture can be achieved extensively within the environment, and that aquaculture holding pens can be created using oyster biorock accretion technology.

Figure 33: Biorock Accretion Technology, seen on a Coral Reef

Metrics for Site Selection

Metrics of Need and Ideal Oyster Habitat

Potential sites need to be selected based on where Oysters are viable, both currently, and historically. The Army corps of Engineers estimates that there need to be between 36000 and 72000 acres of oyster restoration for the Chesapeake to be able to hit a 'viability minimum' for recovery.



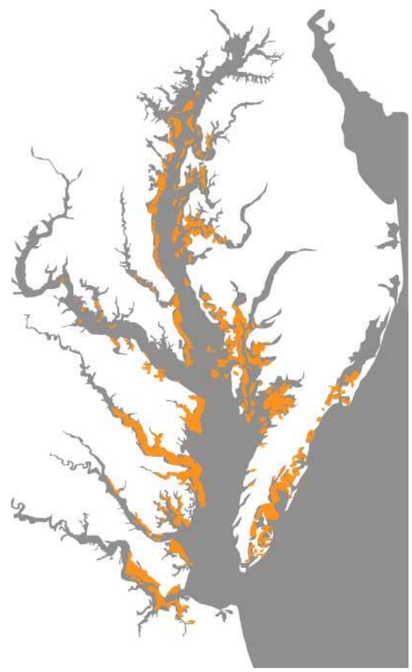
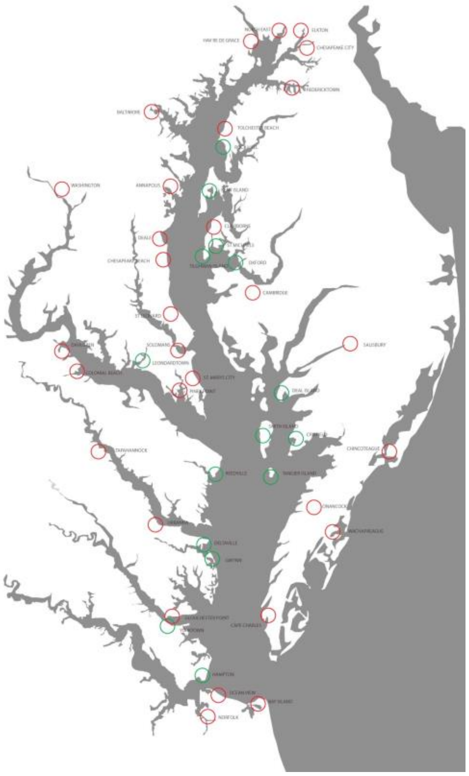


Figure 34: Historic Yeats and Baylor Oyster Bars – Image by Author.
Figure 35: Volume of Oyster Restoration Needed - Image by Author.

Areas of Remaining Watermen Culture

The below map shows the location of existing waterfront towns on the Chesapeake Bay. This map includes both towns that present characteristics of commercial fishing activity (What is to be considered a marker of presence of "tidewater culture"), and towns and cities that don't present this. This data was compiled through a visual analysis and survey of the Chesapeake Bay. Locations with no data compiled were not considered.



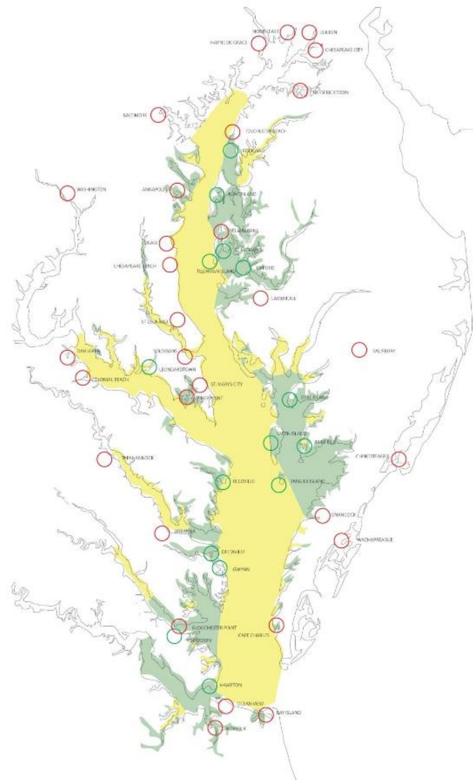


Figure 36: Tidewater Towns with commercial fishing activity in green – Image By Author
Figure 37 ACOE Restorable areas: Overlapped with Tidewater Towns – Image by Author

Areas of Opportunity

Considering that we need to restore a minimum of 36000 acres of oyster bottom per the ACOE projections, there is a tremendous opportunity to use this as a regional design tactic.

Overlaying all of the previously cited data, it is possible to split the metrics of needed oyster restoration up within tidewater towns that still display some commercial fishing activity. Combining this information further with the ACOE's health index for oyster restoration, we find that there are a series of regions suitable for potential aquaculture. The below diagram illustrates these potential sites as they are distributed in the region.

This thesis is focusing on the Maryland portion of the Chesapeake Bay, so three candidate sites were chosen in Maryland, on the Eastern Shore, for further analysis. These sites included Rock Hall, Maryland, in the upper Eastern Shore, Tilghman Island, Maryland, and Crisfield Maryland, near the bottom of Maryland. These will be explored further in the next section.

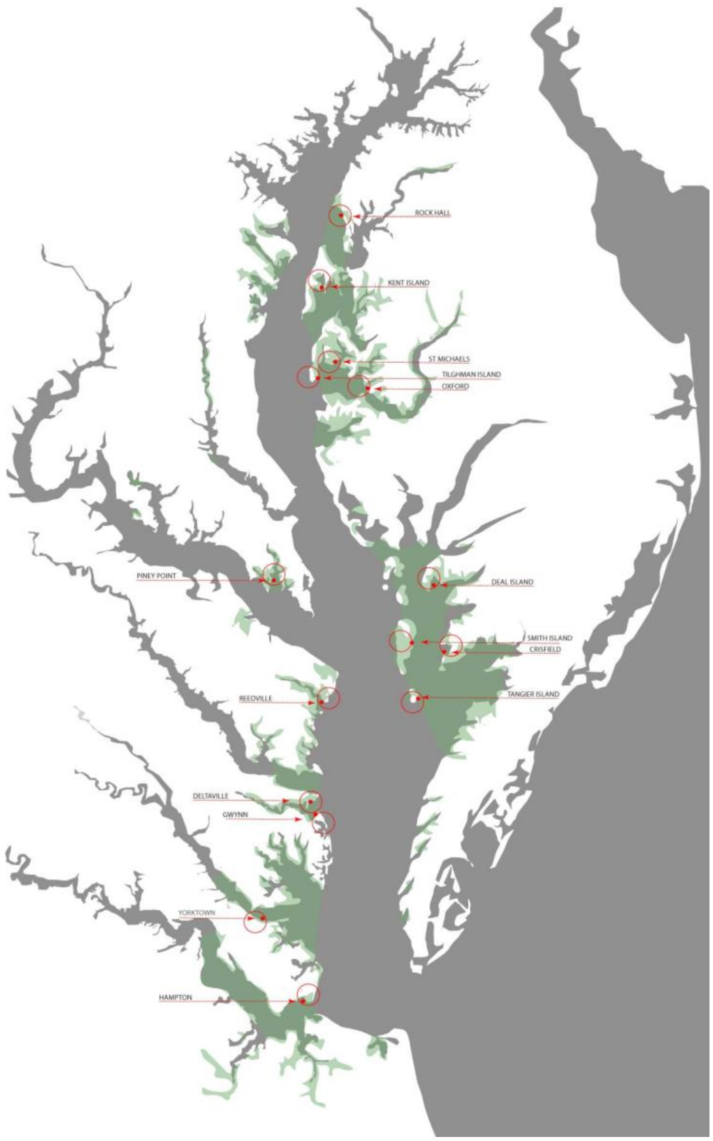


Figure 38: Suitable Tidewater Towns for Oyster Aquaculture Integration – Image by Author

<u>Application of Aquaculture Installations in Typical Towns</u>

Using the sites selected above, Three studies were generated running under the assumption that an existing legal framework can be used, and perhaps modified. In Maryland, bay bottom in oyster sanctuaries is available for leasing by private individuals. In practice, this rarely occurs, potentially, it could be possible for an intrepid businessman or public-private entity to create such an installation. With this in mind, the next step is to examine candidate sites in the Chesapeake which have a critical mass of offshore area near or within an existing oyster sanctuary.

Study A: Rock Hall, Maryland

The first study was conducted in Rock Hall, Maryland. Rock hall is located east of Baltimore, in Salinity Zone A. Since the salinity is lower in the upper reaches of the bay, oyster growth is restricted to deeper waters. Analysis of historical oyster bar locations in rock hall indicate that the ideal growing location is between 12 and 30 feet in this area.

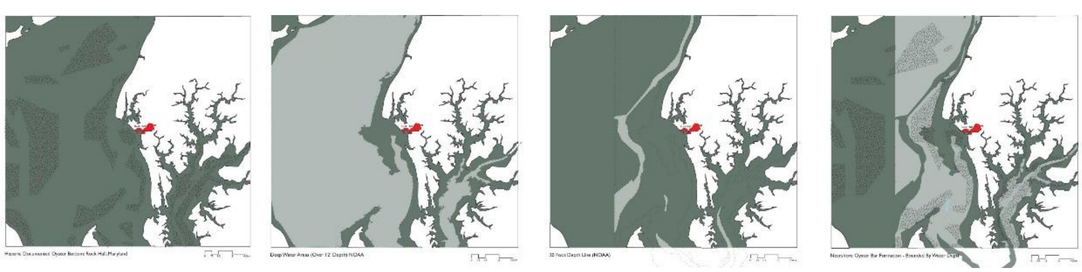


Figure 39 Historical Oyster Bar Analysis and Morphology: Rock Hall MD – Image by Author

Environmental quality notwithstanding, within the confines of the existing oyster sanctuaries in Rock Hall, it is possible to create 2400 acres of leased oyster plots. These were located within the ideal water depth habitat for oysters of this region, and were also strung within a quarter mile of the coastline, for ease of access and protection.

Thus, oyster aquaculture in Rock Hall is viable, but a deeper water solution is needed. In this region, biorock meshes can still be used as a potential accretion armature for oysters, but they will not be visible to the layperson, and will not operate as a coastal buffer. In such a case biorock may not be the most appropriate method of oyster culture, and 30 foot pens for mariculture may be inappropriate as well. A rack and line system here may be effective, though. An aquaculture operation here would be primarily a commercial venture with a side effect of cleaning up the local water column.

Study B: Tilghman Island, Maryland

The second study was conducted in the area surrounding Tilghman Island, Maryland. Tilghman Island is in salinity zone B. Here, the slightly higher salinity levels have modified the ideal growing habitat for oysters. This is again based on historical oyster growth analysis. The analysis of historic data indicates that an ideal growing location near Tilghman Island lies in areas between 6 and 30 feet of depth.

Figure 40: Historical Oyster Bar Analysis And Morphology: Tilghman Island MD – Image by Author

Tilghman Island is another area that has existing oyster sanctuaries. Within the confines of existing sanctuaries solely within a half mile of the shoreline of the island. It is possible to fit approximately 2120 acres of leased bottom aquaculture broken up into 40 acre biorock plots.

The character of a potential aquaculture installation in this area is very different than the character of one in Rock Hall. In Rock Hall, the aquaculture pens are strung down the main channel of The Chesapeake bay. At Tilghman Island, the majority of the oyster sanctuary lies within Harris Creek. The average depth of the region of Harris Creek that the aquaculture installation fits within is only about 10 feet, and there are large enough contiguous areas of water at the 6 foot depth line that would be suitable oyster habitat. At low tide, in this area it could be possible to wade into some of these pens, potentially creating a more tactile environment.

As was the case at Rock Hall, notwithstanding other environmental stressors, oyster aquaculture in the Tilghman Island area is viable. The water depth is more amicable to an intervention at the human scale, in this case. Biorock pens could be used in this region, but again, they would not be able to be used as a breakwater for habitat or shoreline protection. However, the lower total depth of water in this zone makes the potential for mesh nets more viable.

Research into Tilghman Island revealed the proximity of the site to the horn point oyster hatchery, and the Harris Creek oyster restoration project.[91] While an aquaculture installation here is academically viable, it would be directly competing with an environmental sanctuary that is undergoing active restoration.

[91] NOAA: Habitat Blueprint: Delmarva/Choptank River Complex

Study C: Crisfield, Maryland

The third study of the application of a large scale aquaculture installation was done in the Tangier Sound near Crisfield, Maryland. Crisfield is located in salinity zone C. It is the largest settlement in Maryland within this high salinity zone (the majority of high salinity bay towns are within Virginia.)

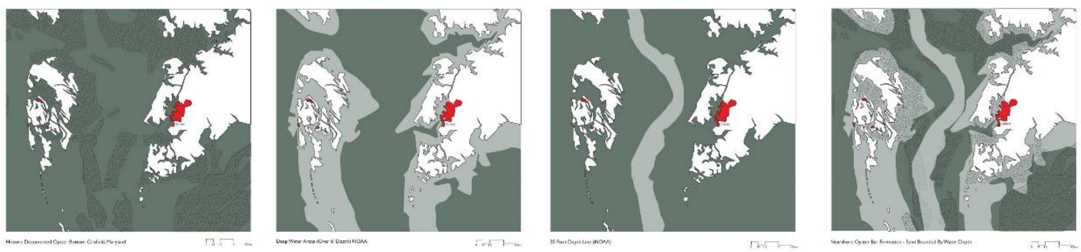


Figure 41: Historical Oyster Bar Analysis and Morphology: Crisfield MD – Image by Author

The geometry of historical oyster analysis in this region indicates that while the 30 foot maximum depth line seems to hold steady, In Crisfield, the latent level of salinity allows oyster bars to extend out almost to the shore line. In terms of using biorock oyster gabions as a breakwater, this region is perhaps the most ripe for further examination of this methodology. Another supporting factor of the Tangier sound region as a site is the viability of the breakwater. The swing of the tide is around 2-3 feet in water depth change, twice daily. Properly assembled, aquaculture pens here could completely isolate environments for large portions of the bay. This is good for both habitat restoration and protection, and is also an ideal environment for creating fishery pens. Much less material would need to be used here than would be necessary in Tilghman or Rock Hall. Finally, the visibility of oyster breakwaters here would be effective for creating awareness of these issues, and the environmental machines that might be their solution.

Unlike in Rock Hall or Tilghman Island however, there are no oyster sanctuaries within the proximity of Crisfield. (This is probably due to the lobbying efforts of Crisfield watermen, the oyster flats here are still somewhat productive.) This does not mean that there is no need for a resilient solution, however. It just indicates that commercial aquaculture in this area might not be enough justification to get through legal hurdles. With such a concern of sea level rise in this region, examining the resilient coastline first and the aquaculture second may be more effective here.

Takeaway: The Viability of Large Scale Aquaculture

These studies indicate that there are ample prime locations for large scale aquaculture operations in the Chesapeake. All three of the studies explored solutions of aquaculture that ranges into the thousands of acres, and considering the manpower required to run these facilities and the infrastructure that could be revitalized when it is implemented, they have the effect of generating commercial activity and creating a reason for being in many of the smaller communities on the Chesapeake that have lost this.

Conclusion: Final Site Selection

The Case for Southern Maryland

While there are undoubtedly many methods of fostering coastal resilience, this thesis is proposing a method of designing for environmental degradation, sea level rise, collapsing fisheries, and disappearing waterman culture, that is based on the implementation of oyster breakwaters that are arranged in a manner to regenerate environments. In the Maryland region, the areas that have to work with all of these concerns simultaneously are limited to the southern region. Exploring a solution that uses aquaculture as a primary methodology will be most viable in these southern regions.

The western shore is ruled out due to its geology. While there is a fair bit of erosion occurring on the Western Shore, there is much less of an immediate threat placed on western shore communities from sea level rise or subsidence. Thus, the remaining candidate location that is viable is the southern Eastern Shore, and perhaps the Chesapeake island communities in this region.

Final Site Selection: Crisfield/Smith Island

Narrowing down to the South Eastern Shore of Maryland, Crisfield and the nearby Smith Island communities were ultimately selected. These locations were selected because they are the major settlements in this region, and also because they have the 'perfect storm' of environmental issues to tackle. Further, the waterman culture is still strong here, much of the soft shell crab industry has relocated to Crisfield since the inhabitants of Smith Island are their remaining suppliers.

Additionally, Crisfield and Smith Island exist as a unique pairing in the Chesapeake Bay. Since many of the island communities are threatened, or have been bridged to the regional road network, there are few places that are truly isolated that remain in the Chesapeake. There is a potential touristic draw with this situation. Looking back at how aquaculture can be paired with ecotourism, capitalizing on the existence of the ferry route between Crisfield and Smith Island seems to be a natural extension of this.

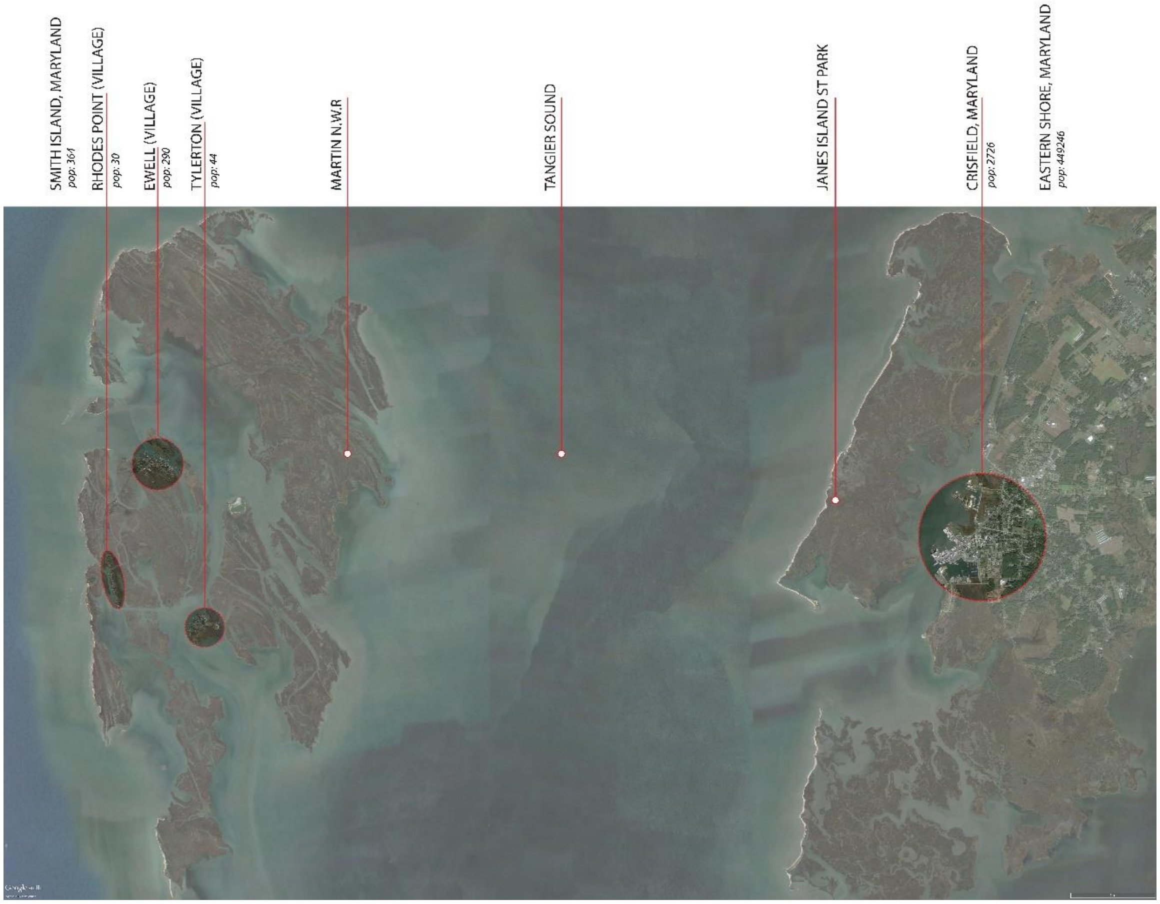


Figure 42: Smith Island, Maryland (left) and Crisfield, Maryland (right) – Image by Author

Chapter 6: Design Proposal

Program Selection

The program eventually selected was primarily an oyster aquaculture facility, with support structures to run the operation, with a secondary aquaculture ecotourism trail component, designed to bring people into the environment and foster stewardship and understanding of the tidewater culture. It was determined that this would necessitate a large scale environment with a split program, the program was split into four major components. Below is a diagram of a potential aquaculture ecotourism trail.

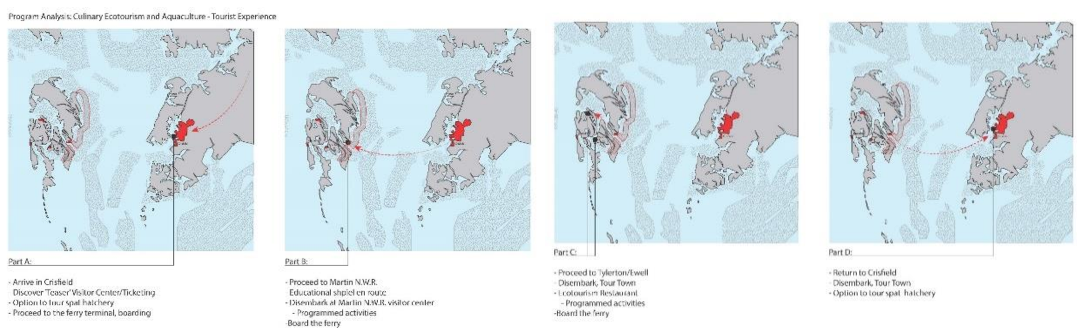


Figure 43: Aquaculture Ecotourism Trail Sequence – Image by Author

The split environment program brings up many opportunities – it allows for each of the elements to be developed seperately, and having a sequence of events can create a narrative element that can satisfy the educational aspect of this thesis. The final form of this narrative series of interventions is seen in figure 46.

Aquaculture Siting

After determining what the appropriate program might be, it became clear that the most difficult object to site would be the aquaculture component. The Tangier sound runs through the channel between Crisfield, and Smith Island. This is realistically the only location that aquaculture could be sited in this region, since moving out to the west of Smith Island becomes impractical. The Army corps of Engineers has already taken traditional measures to protect the western edge of the island, they have created a series of living breakwaters, riprap, and sand buildup interventions to protect this area.[92] Further, the environment west of Smith Island is of poorer quality[93], and an aquaculture intervention might have trouble establishing itself in such an environment.

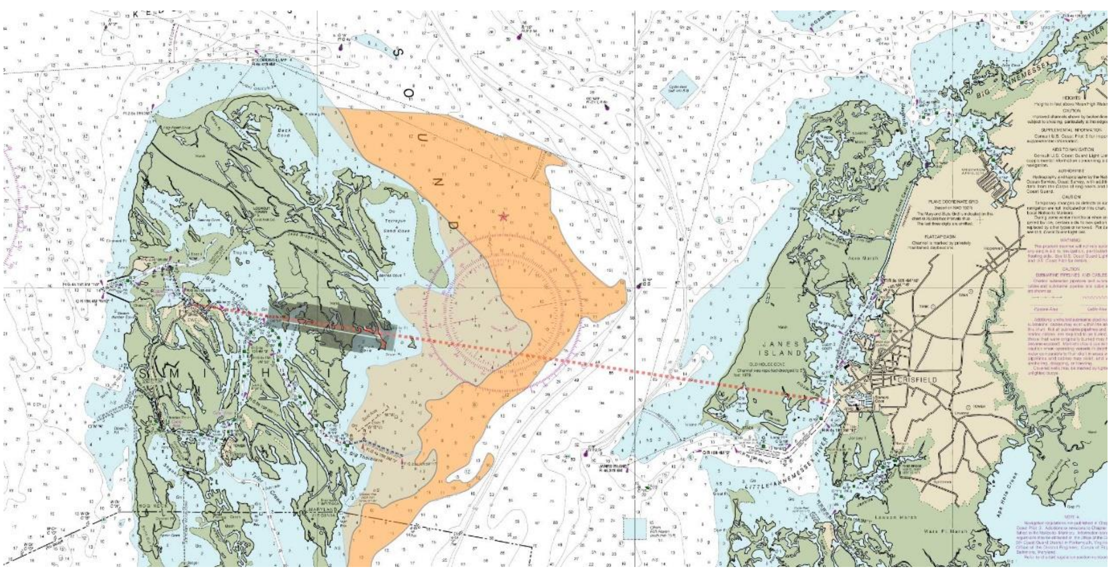


Figure 44: Zones of Ideal Oster Habitat Bounded by water depth. –Image by Author

[92] US Fish and Wildlife Service, "Fog Point Living Shoreline Project"
[93] Army Corps of Engineers

The first step taken in determining site suitability for an aquaculture intervention was done through looking at historical oyster bar locations, and extrapolating this data to determine the ideal oyster depth habitats in this portion of the Chesapeake Bay. These maps showed that the salinity in the Crisfield area was high enough to allow oysters to survive in water as shallow as 1-2 feet, but that oysters are still limited to growing in regions with a maximum of 30 foot depth. Since this is a commercial installation and not simply a restoration project, the water depth needed to be taken into account for the draft access for oystering and maintenance boats. The above diagram marks out suitable habitat, with the darker orange region being suitable habitat over 4 feet in depth. This environment is ideal for both oysters and the vessels that will need to harvest them.

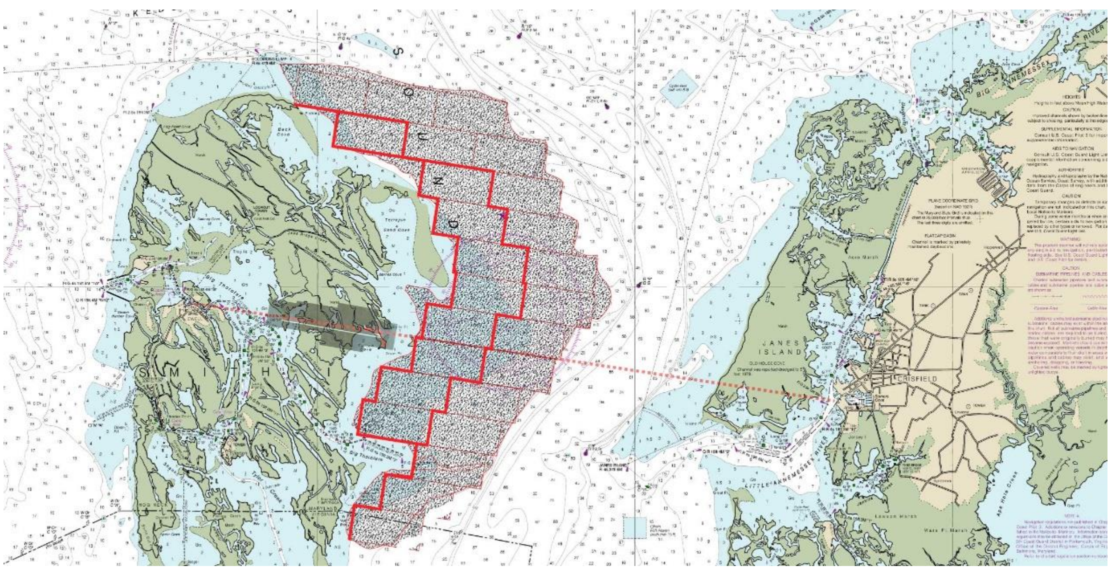


Figure 45: Aquaculture Pen Siting and breakwater potential siting – Image by Author

The second step in the siting process was determining how to best break up this region into suitable aquaculture pens. It is easier to handle an aquaculture system when the pens are of a roughly consistent size, this is seen in the example of Veta La Palma earlier. 80 acre pens were selected for reference and they were allowed to stagger in location to maximize their footprint. 25 80 acre pens were able to fit within the suitable aquaculture zones. Further, since these pens will need to be marked out with netting of some sort, it was determined that it would be best to run the breakwater along the perimeter of these pens. This minimizes the amount of breakwater that will need to be constructed while also minimizing the amount of pen to net. The above diagram shows two potential breakwater alignments, one near the shore, and one a mile further offshore.

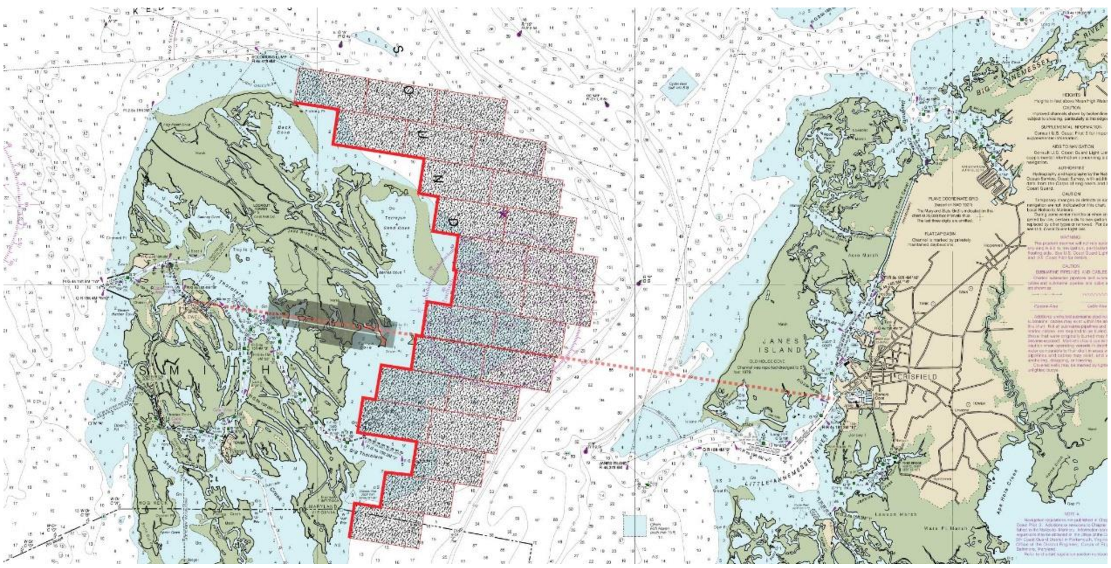


Figure 46: Final Aquaculture Siting Location – Image by Author

For the final site selection for the aquaculture portion of the installation, the nearshore breakwater option was chosen. Since the breakwater effect is greater the nearer it gets to shore, the amount of wave energy reduced with a nearshore breakwater will be greater than a breakwater situated a mile further offshore. This also allows for the possibility of later constructing additional breakwaters at the other pen boundaries, should there be a need to reduce further the wave energy with more breakwaters.

Final Design Proposal

Since the intervention is at both a landscape scale, and at an architectural scale, and the distance between Ewell and Crisfield is over 9.5 miles, the design interventions were broken into multiple components. These include:

I: The Tangier Sound Aquaculture Co.

II: The Somers Cove Oyster Hatchery

III: Bar Crassostrea

IIII: The Sea Level Rise Path

These four program components are distributed axially along the site line between Ewell, and Crisfield. These program elements will be accessible by passenger ferry, and alternatively private water vessels.

The linear nature of the arrangement is designed to construct an educational narrative as one proceeds through the tour. Starting at the Somers Cove Oyster Hatchery, the operational process of the oyster hatchery is explained to the visitor. Moving to the Tangier Sound Aquaculture Co. Second, the visitor understands the role that oysters play in the breakwater construction and maintenance schemes within the aquaculture pens, and the process of moving through this installation will educate the visitor in its role in protecting the island that lies beyond the aquaculture. Also on the water route between Crisfield and Smith Island are the series of architectural follies. The first folly, “Surge” shows the visitor what the sea level will look like in the future. The second folly, “Energy”, educates the visitor about the dissipating effect of the oyster breakwater. The third folly, “Accrete”, shows a visitor how the landforms in this environment grow and shift over time. Finally, the site line ends at

Bar Crassostrea. This program element is an oyster bar and grill, here the guest is allowed to complete their journey by immersing themselves in oyster culture – a cuisine based environment is used to help people best understand their role within the environment.

Tangier Sound Aquaculture Co.

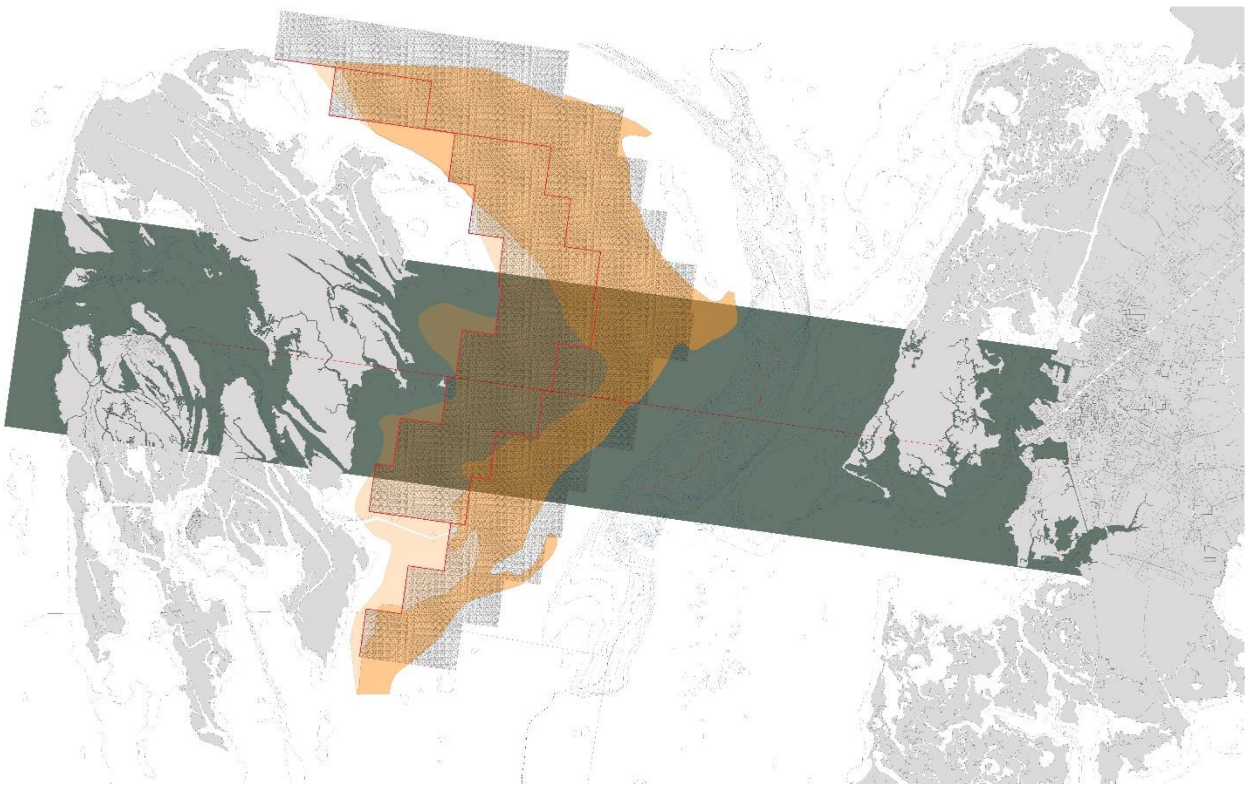


Figure 47 Tangier Sound Aquaculture Siting: Image by Author

The Tangier Sound Aquaculture Company is the largest single component of the program. It consists of 2000 acres of oyster aquaculture, which is broken up into 25 80 Acre sited aquaculture pens. These pens are bracketed on one end by a biorock breakwater gabion, and sit adjacent to each other to form a continuous breakwater. The image below shows how this breakwater is designed operate at its full grow out.

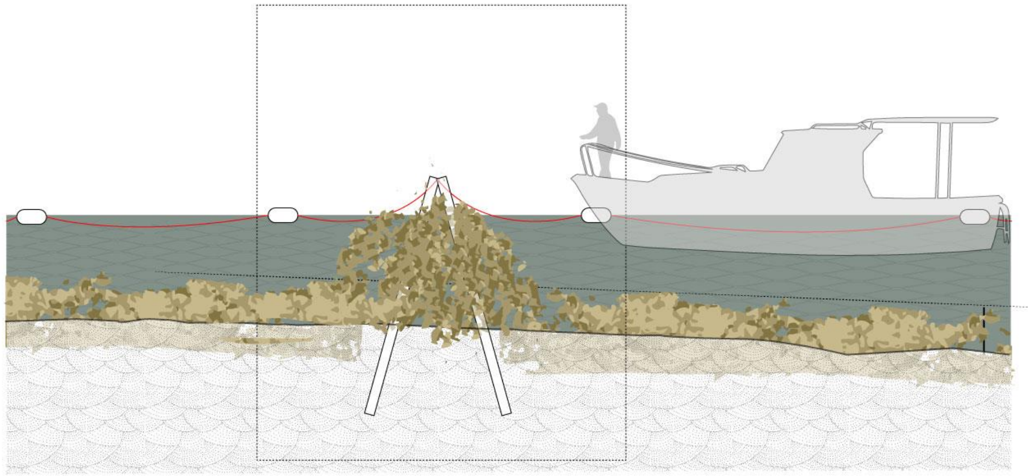


Figure 48: Oyster Breakwater: Final grow out. Image by Author

Since oysters grow over time from an almost invisible spat to it takes about 2 years for a Virginia oyster to reach harvestable size, Spat can be affixed to a steel wire mesh onshore and brought to the breakwater location for initial construction as a typical offshore fence. These fencing segments will be prepared onshore at the Oyster Hatchery.

As the oysters grow to their full adult size (which takes about 6 years), they will naturally infill and form an organic breakwater around the mesh framework. Over time, the breakwater will not need to be maintained. Unlike a traditional concrete oyster bar framework, the biorock gabion breakwater should be quicker and easier to construct. The below diagram illustrates how this construction and growth process might occur.

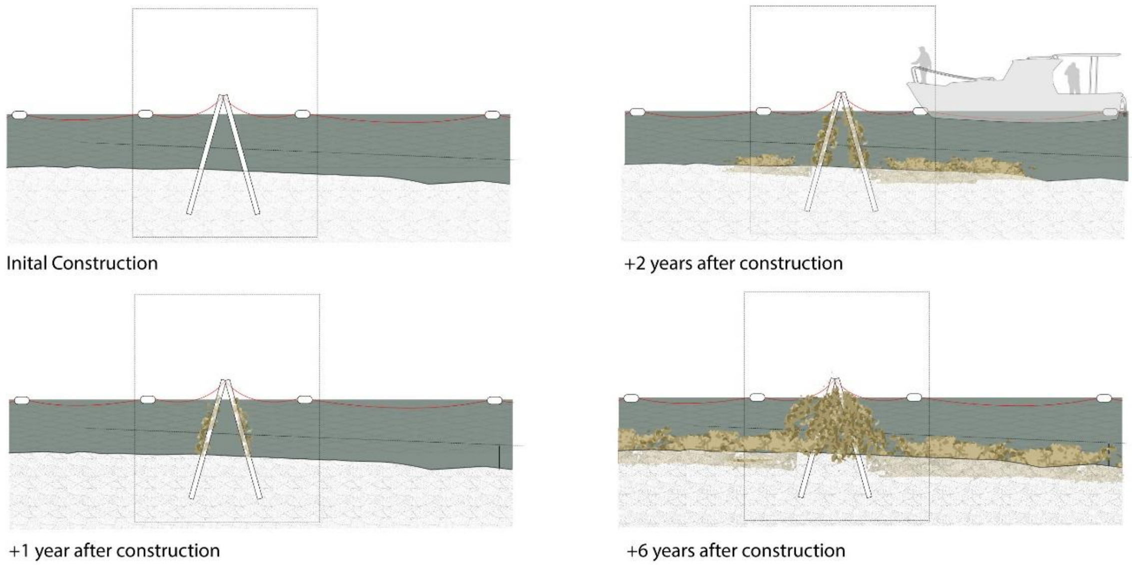


Figure 49 Breakwater Growth over Time: Image by Author

Within each 80 acre pens are 104 separate oyster seeding locations. In this system, oysters are seeded on the bay bottom and harvested as they reach maturity. These are ordered in a grid system to facilitate ease of harvest and maintenance. Within these pens, additional forms of extensive aquaculture beyond oyster aquaculture can be practiced, this thesis suggests that Rockfish aquaculture could be practiced within these pens, as the pens are netted along their edges to facilitate finfish aquaculture. The large scale of the pens will allow for this to occur without needing additional nutrients to supplement fish growth.

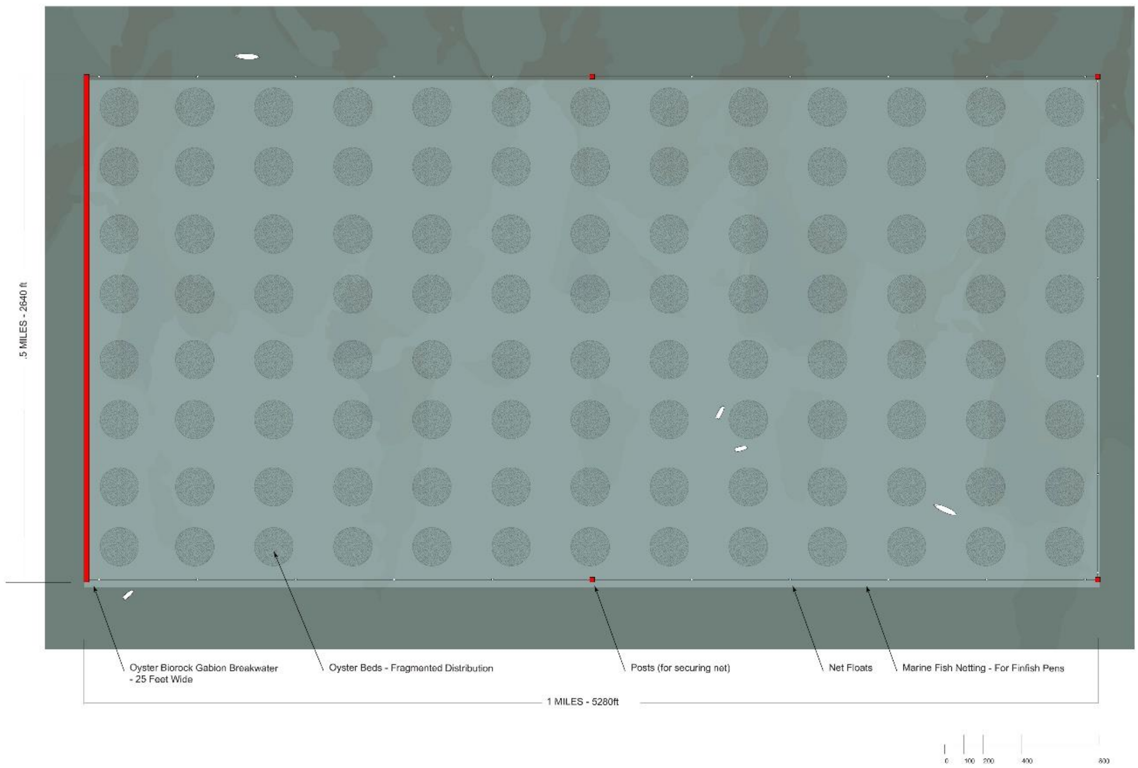


Figure 50: Typical Aquaculture Pen, Showing Seeding Locations. Image by Author

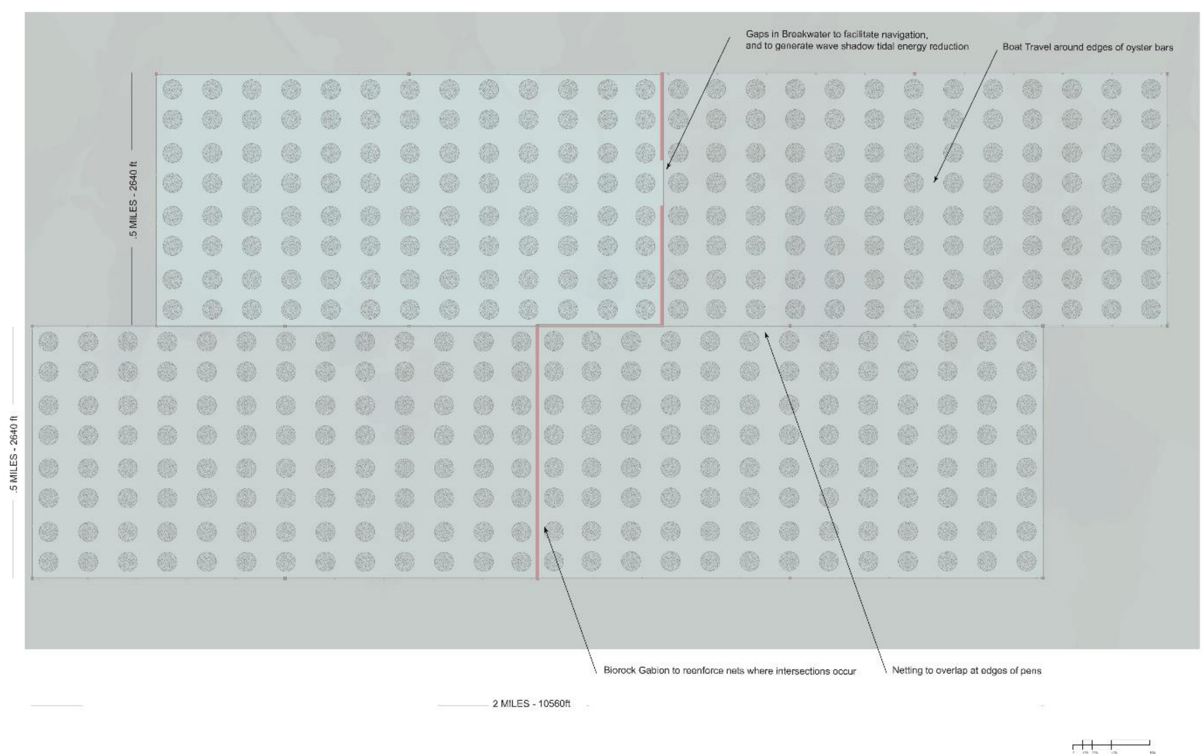


Figure 51: Typical Arrangement, Multiple Pens. Image by Author

It is estimated that each 80 acre pen will be able to produce a maximum 176,000 bushels of harvestable oyster a year, and that the total capacity of the site will be able to yield 4,400,000 bushels, assuming a 100% harvest rate. Allowing for a harvest rotation, a typical season might yield 1,000,000 bushels of oyster for sale, assuming that oyster growth is on a 4 year rotation.

Somers Cove Oyster Hatchery

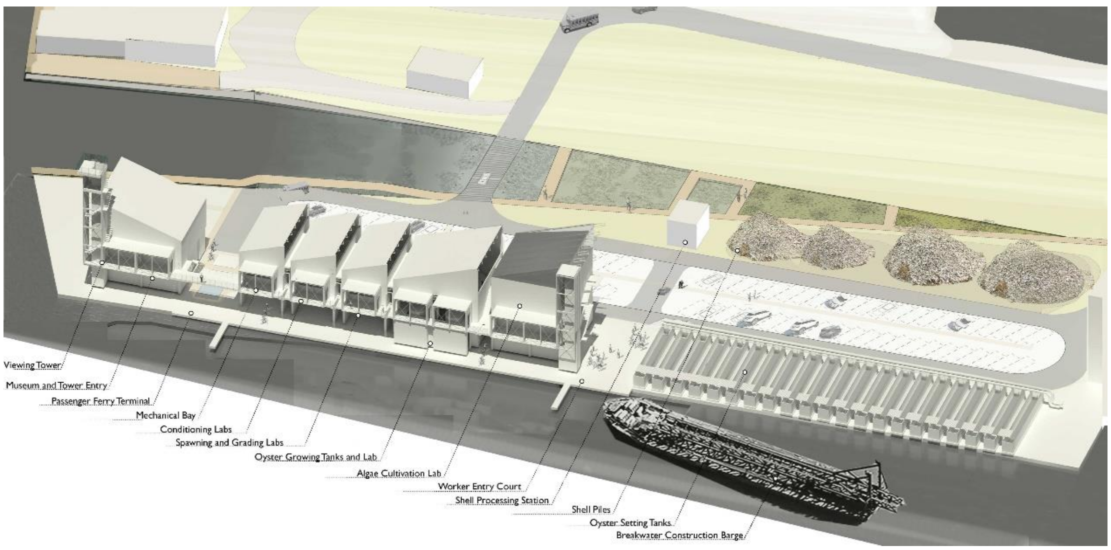


Figure 52: Somers Cove Oyster Hatchery Aerial – Image by Author.

Somers Cove Oyster Hatchery is located near the southwestern edge of Crisfield, on the Somers Jersey Island. It faces outwards to the Chesapeake, on relatively open water. Since the program requires a large open site, Somers Jersey Island was chosen as the site had previously been cleared for a residential development which never occurred, and is thus in need of revitalization. Further, the site is surrounded by water on three sides, which allows for easy waterfront access for the large amount of boat traffic that such a facility will generate.

Illustration 14: Somers Cove Oyster Hatchery Site Plan – Image by Author

Somers Cove Oyster Hatchery takes its program precedent cues from Horn Point oyster hatchery, which was discussed in chapter 4. The majority of the program is centered on the hatchery process, but mechanical, office, and lab spaces are also included, along with guest services and a visitor center.

The major design challenge of this facility was figuring out how to integrate the needs of the oyster hatchery (and the needs of the support staff who will run it), with the needs of the educational component. Since it is not ideal for tourists and scientists and workers to constantly be interacting, the building took the form of a spine parti, with the spine pushed to the waterfront face of the building. This spine is neither fully open nor enclosed, since it is part of a tourist sequence it became evident that it was more important for this element to reinforce the idea of the linear narrative. As the guest proceeds down this linear path, the spine takes them both inside and outside, so that each of the rooms where oyster rearing takes place is understood as a separate 'scene' One enters a room, exits onto a balcony, and then enters into the next room. This allows the connection between the landscape and environment and hatchery facilities to become front and center.

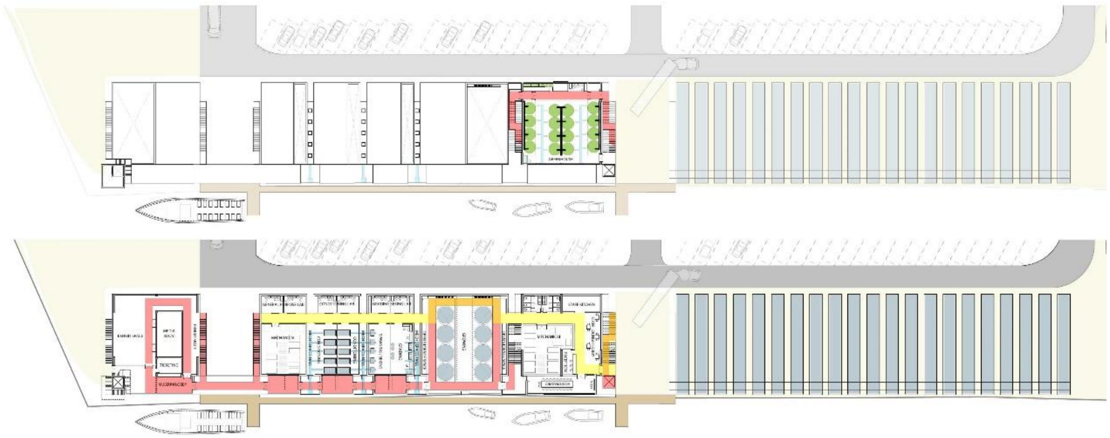


Illustration 15: Hatchery Plans. Image By Author.

The building consists of a series of bays that separate program elements, these are all aligned along a circulatory spine. The primary program requirements are borrowed from Horn Point Oyster Hatchery, discussed in Chapter Four. In Somers Cove, Each bay aligns with a certain program element. The arrangement of these bays was determined based on the linear nature of the oyster rearing process, and the process is drawn out in a linear sequence to ease understanding.

The first bay on the tour route is dedicated to the conditioning rooms.

Illustration 16: View of the Conditioning Rooms – Image by Author

The second bay on the route is dedicated to the sexing and spawning rooms.

Illustration 17: View of Sexing Table Labs. Image by Author.

The third bay is dedicated to the growing tanks.

Illustration 18: View of Growing Tank Room. Image by Author.

After proceeding through this zone, the guests have the option to proceed upstairs and view the greenhouse, and then they exit the building a final time and are invited to walk along the setting tanks.

Illustration 19: View of Setting Tanks. Image by Author.

The circulation of the building is designed so it is possible for the workers to be able to go about their day without needing to interact with the guests. Within the bays, there is an additional circulation corridor which connects the rear of the bays with the worker entry and lab spaces.

Since the building is within a flood zone, and the sea level in Crisfield is expected to rise a half a foot every 30 years, the entire building is raised 14 feet on piers. These piers are heavy concrete pilings, and the space below them is dedicated to boat and vehicle storage, as well as areas for locker rooms, guest restrooms, the pump room, and other programs that may flood occasionally. In a flood event, it is still possible to access the upper level of the building by using the pedestrian bridge connecting the visitor's center to the laboratory spaces as a dock.

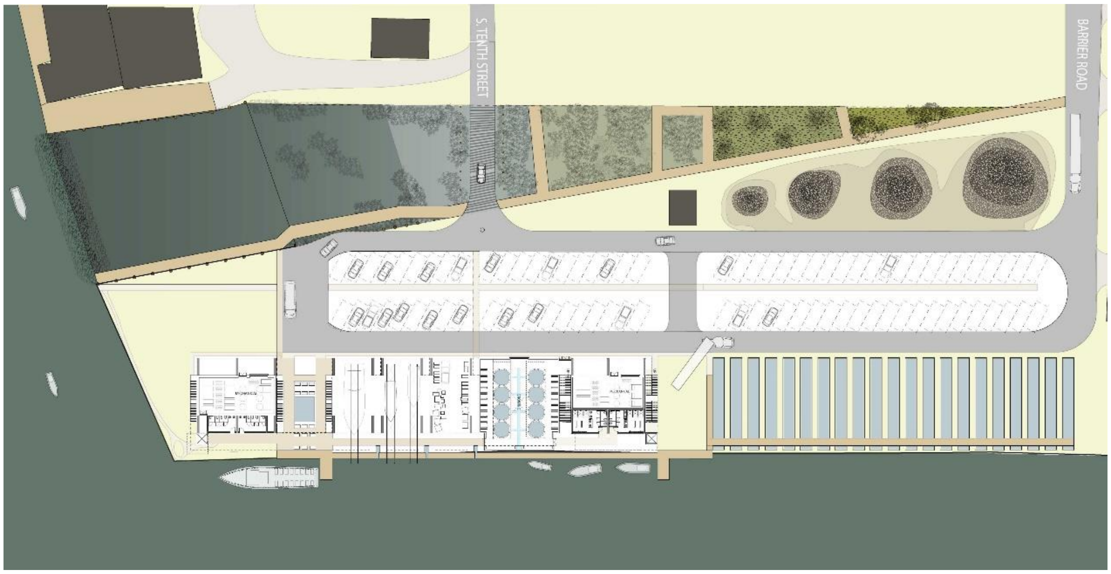


Illustration 20: Ground Floor Plan and Bioretention System. Image by Author.

Looking at the site plan, a large amount of space has been dedicated to a bioretention facility. Instead of using smaller separate bioretention ponds, it was more efficient to combine these into one site. The bioretention pond illustrates the idea of the transect from land to sea in the Chesapeake: further inland the land is solid, but walking along the entire bioretention area you see land give way to upland marshes, then lowland marshes, intertidal flats, shallow water, then an oyster bar. Essentially, the bioretention pond acts as an additional educational element for the guests to understand how the landscape constructs, changes over time and with the tide, and drains itself.

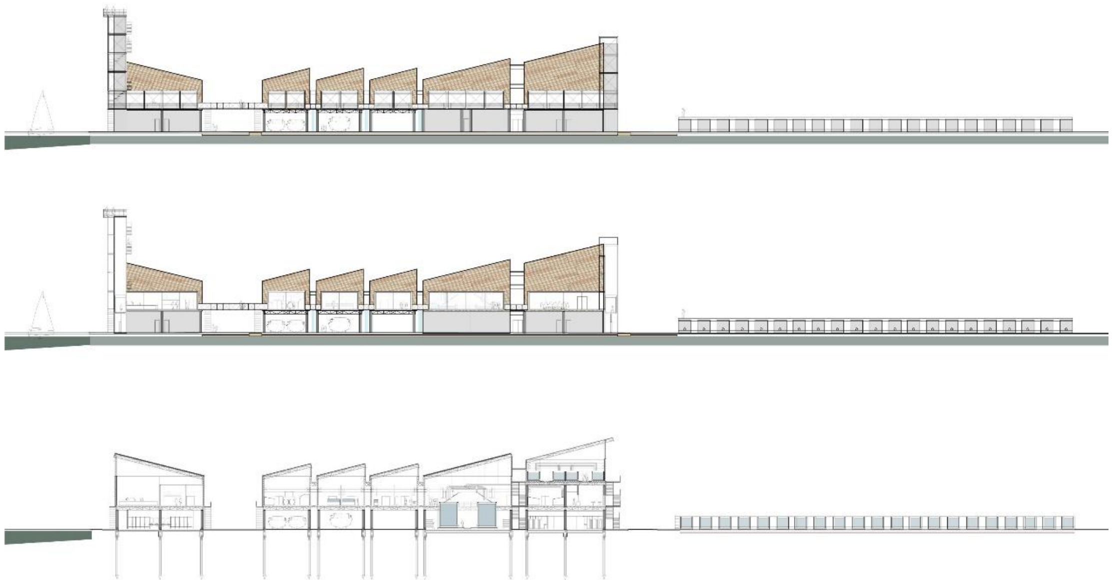


Illustration 21: Hatchery Elevations and Sections. Image by Author

In section, Somers Cove Oyster Hatchery can be understood as an industrial space elevated on a plinth. To experience the interior spaces, one must ascend 14 feet vertically. To differentiate the façade, a saw tooth roof pattern was used to allow for natural daylighting, and the bays were offset from each other with the use of 4' mechanical corridors where floor drains and mechanical supplies are present. Either end of the building is bracketed by elevator towers, the tower on the visitor center side is climbable, and additionally serves as an observation tower and an architectural folly that will be discussed later.

The entire hatchery serves the purpose of reinforcing the linear narrative of the site. In this location, the visitor gets the chance to see and understand the oyster rearing process, it becomes a process that is essentially venerated and elevated, and is no longer just an abstract understanding of the Oyster.

Bar Crassostrea

Illustration 22: Bar Crassostrea, Aerial View.

The restaurant is situated in the center of Ewell, the largest village on Smith Island. Keeping with the context of the site, Bar Crassotrea's location was chosen so that it can reinforce the small village center, and can act as an armature of expansion in the village. As the site plan below shows, Bar Crassostrea is located near the public marina to the north, the main cross streets, the working marina to the west, and also near the Smith Island Heritage Center on the east. Centrally locating the restaurant will allow for visitors to easily locate it, but will also allow for visitors to explore Smith Island before and after their meal.

Illustration 23: Ewell Site Plan, Including Bar Crassostrea - Image by Author.

Bar Crassostrea is located near the boundary of the working marina and residential areas so it is able to pull from the vernacular architecture of the site. The vernacular commercial structures, most of which are crabbing shanties and offshore workrooms, has a unique typology which is native to the Chesapeake Tidewater. Crab shanties are typically built partially or fully offshore on stilts, with a low roof slope, ribbon windows, and light frame construction. The image below shows such a crab shanty in Ewell. Further, the layout of these structures is also unique in design. Since these structures are accretive in nature, with additional buildings being ganged together as needed by the individual waterman, there are a set series of layouts of these structures that can be referenced. The diagram sets below illustrates many of these potential arrangements.

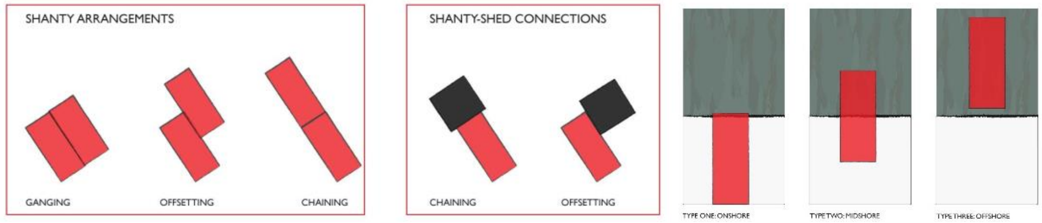


Illustration 24: Shanty Arrangement Typologies - Image by Author.

This is a unique artifact of culture that should be preserved and elevated, and the design and construction of Bar Crassostrea is intended to reference the native watermen vernacular commercial architecture of the region. It is intended that this will help strengthen the sense of place and feeling of being within the Tidewater Environment.

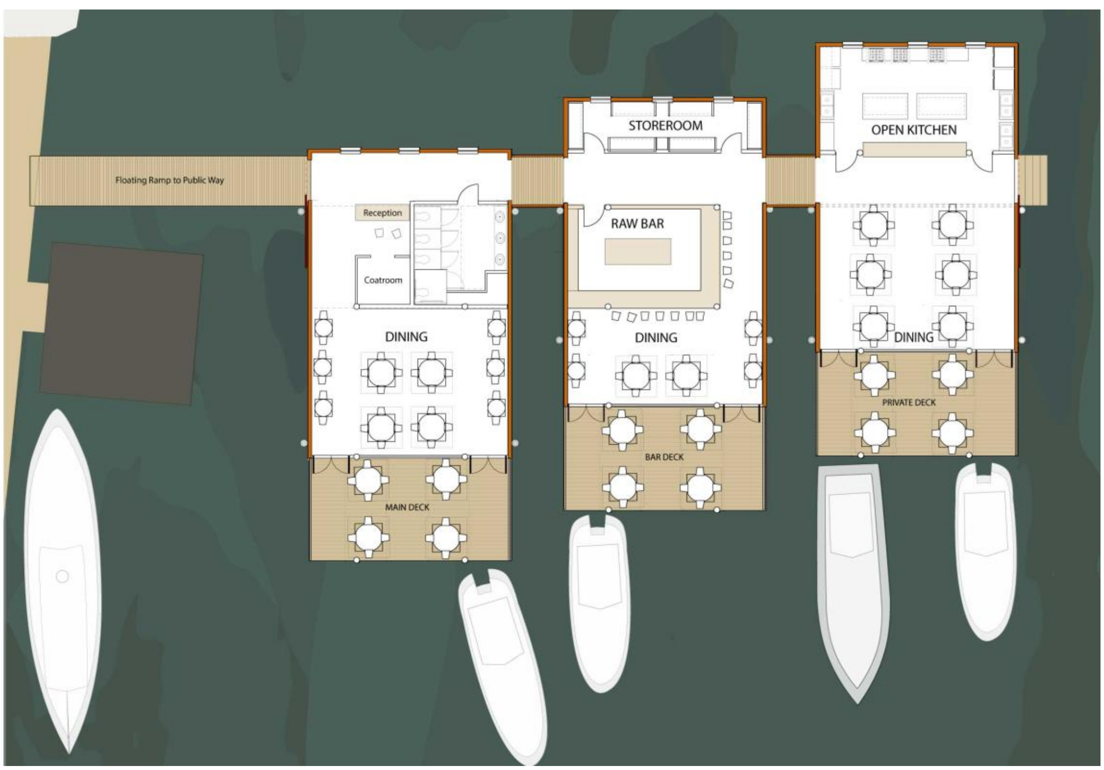


Illustration 25: Bar Crassostrea: Plan - Image By Author.

Bar Crassostrea is designed as a waterfront boat access restaurant. It has a secondary access to the public dock, leading to the center of town. It is broken into a series of three restaurant modules, connected by an enclosed circulation spine. It is constructed of timber, with Eastern Cedar cladding, in reference to the vernacular construction methods nearby. It is designed to be resilient to sea level rise. On a typical day, the building rests on top of a pile-driven wooden foundation. This allows it to be as close to the water level as possible, so it will be possible for a guest to enter directly from their personal water craft. In a storm event, the water level will potentially be highly variable on Smith Island, even with offshore breakwaters. To manage these flood events, Bar Crassostrea has an additional series of guide posts on the exterior of each module. These are connected to the main structure with a number of steel sleeves. Fiberglass foam floats line the underside of the building, and in a storm event, the design of the sleeves allow for the building to move up and down vertically with the tidal storm events. Further, the connecting corridors are designed as breakaway walls, so there is more flexibility in the movement of the entire structure.

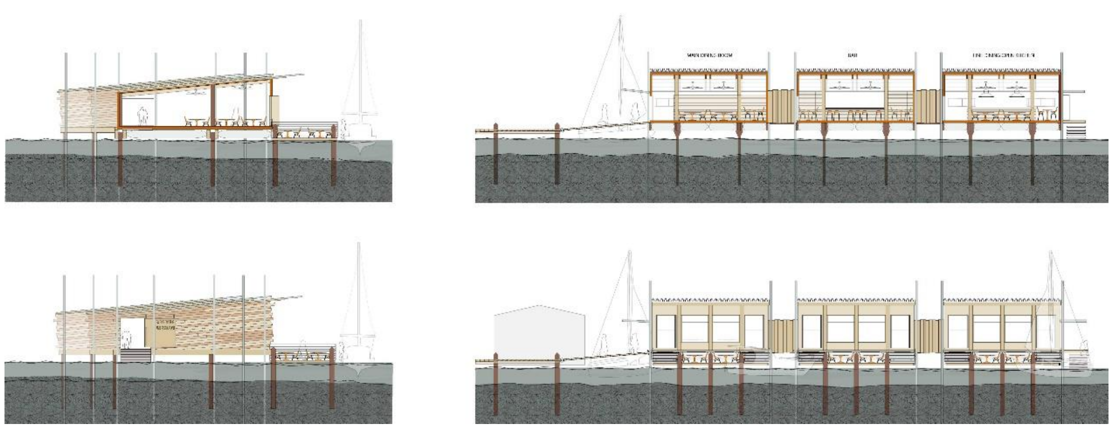


Illustration 26: Bar Crassostrea: Sections and Elevations – Image by Author

The Sea Level Rise Path

The final component of the design intervention is the Sea Level Rise Path. It ties the interventions together, and is composed of a combination of 3 folly elements, and 2 architectural elements (Including the hatchery and restaurant.) As a visitor proceeds through their journey, they are educated about their place within the environment.

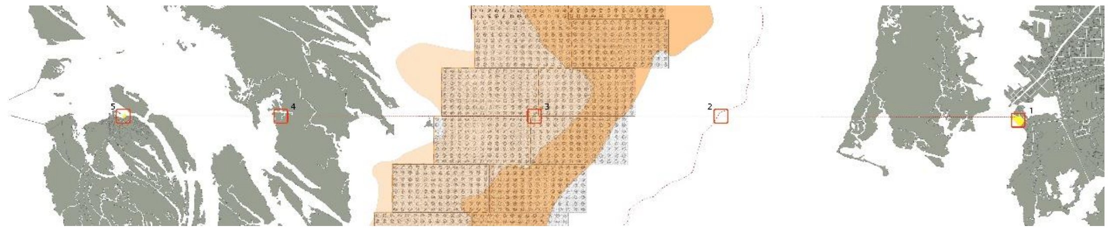


Figure 53: Folly locations along the site line, in ascending order from right to left

At the Oyster Hatchery, the easternmost folly, the 60 foot observation tower "Observe" allows them to see visually the entire environment that they are about to enter. This tells them of the journey they will take through the environment, and also gives them a bird's eye view of the aquaculture as breakwater in action.

In the deepest portion of the tangier sound, the visitor will experience the second element, the Sea Level Rise Buoy, titled "Surge." This folly, by capturing storm water, shows the visitor what the sea level will be at varying dates in the future. This has the intended effect of helping the visitor grasp the massive scale of the sea level rise concern.

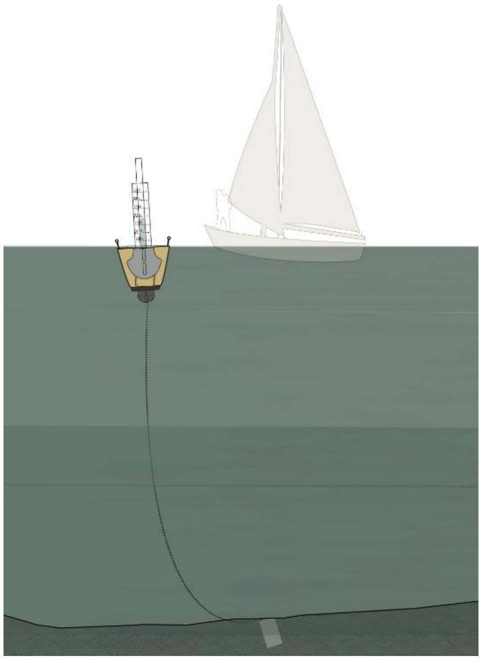


Figure 54: Sea Level Rise Folly - Image by Author.

The third folly is located within the breakwater gabion. This “energy” folly demonstrates the mitigation properties of the breakwater. The image below illustrates the folly's design which consists of a series of vertical floating tubes. The tubes are free to rise and fall with the waves and will show that the amount of wave energy outbound of the breakwater is higher than the amount of energy inbound of the breakwater. Observers will be able to understand the operation of the breakwater as a protective device

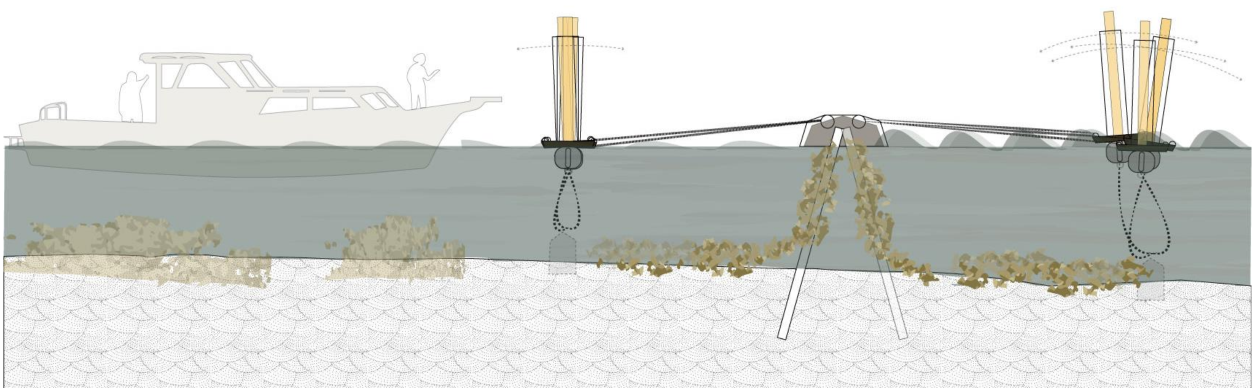


Figure 55: Energy Dissipation Folly - Image by Author.

The next folly is situated on land, within the Martin National Wildlife Refuge. This folly is named “Accrete”, and is situated on a boundary between land, marsh, and water. This folly consists of a series of tubes driven into the ground – these tubes show the current ground level, and as the boundary between water and land changes, they will show where the land has moved from both horizontally and vertically. This will educate the viewer about the fluctuating nature of the environment, and that it is a landscape constantly changing in form.

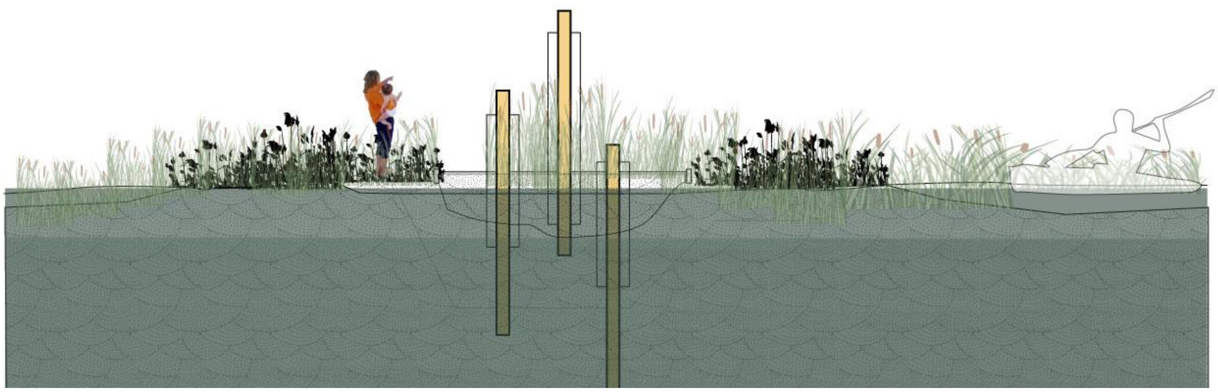


Figure 56: Accretion Folly - Image by Author.

Finally, the restaurant serves as the last element of this sequence. In the restaurant, guests dine right at the water’s edge, on oysters and other regional food that reminds them that their diets are of this place. The passenger ferry and the guests’ boats are situated along the axis, reinforcing the idea that the visitor is part of this sequence.

Chapter 8: Design Conclusions: A Future of Stewardship

Quantifying the Need

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The Chesapeake Bay is out of balance. As the effects of decades of overharvesting, overdevelopment, and pollution have taken their toll, tidewater communities are confronted with a loss of culture, livelihood, and the environment in which they live. This thesis demonstrates that large scale holistic solutions are perhaps the only types of solutions that can work for complex problems such as the plight of the Chesapeake Bay. Small scale "Band-Aids" solutions only address the symptom of the issue. These include what has been done in the past for the Tidewater environment. These simply no longer work. This document has illustrated the scale of the environmental, cultural, and economic threats to the tidewater way of life.

This thesis proposes oysters as the framework from which the revival of the Chesapeake Bay can begin. However the entire crisis cannot be solved with just oyster alone. The 'problem web' (see figure #) illustrates this. Oysters aren't a Deus ex Machina solution to the plight, but are a critical starting point. They are debatably the keystone species of the Chesapeake, and many components of the ecosystem cannot begin to regenerate without a network of oyster bars as seen in the past. As a natural biofilter they will be able to keep the environment healthy long enough to support other species within the environment. This leads us to the topic of the further of inhabitation. Oysters cannot simply be "reintroduced" to the ecosystem due to the state of the Bay. Aquaculture "the cultivation of aquatic animals, plants, shellfish etc." would allow the oysters to grow to a size and age where they can survive the current conditions of the Bay. Further, aquaculture provides an immense opportunity to regenerate the culture of the Chesapeake tidewater community by providing a new livelihood that is reminiscent of the harvesting watermen of the past.

Designing for the recovery of an environment and culture is an important facet of this thesis but cannot be expected to sustain itself. It is the human factor that will determine the long term success of the project. Fostering stewardship through a greater appreciation of the Chesapeake Bay and Tidewater communities is what the architecture and thesis intends to instill upon the project. By bringing people closer to their environments and the process of teaching how nature, farming, and humanity is interconnected, a sense of responsibility is created and we can begin prepare for a future of stewardship.

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