ABSTRACT

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Ghost fishing, caused by derelict fishing gear, poses significant threats to marine biodiversity and ecosystems. The marine biome, covering over 70% of the Earth's surface, is vital for ecological, economic, social, and cultural well-being, yet human activities have led to severe challenges for these ecosystems. Historical examples show how coastal civilizations have thrived due to their access to marine resources, but modern societies have often failed to respect and maintain this harmony. Ghost fishing has detrimental effects on various marine species and communities that rely on marine life for food and economic security. This paper proposes architectural solutions to mitigate the impacts of ghost fishing while emphasizing the need for marine habitat restoration.

CATCHING SOLUTIONS: ARCHITECTURE’S ROLE IN TACKLING GHOST FISHING

by

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Dedication

For my beloved father, who instilled in me this passion for architecture, and my mother and guardian for their hard work!

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List of Abbreviations

ADLFG: Abandoned, Lost, or Otherwise discarded Fishing Gear.

ASMFC: Atlantic States Marine Fisheries Commission.

AUV: Autonomous Underwater Vehicles.

CBF: Chesapeake Bay Foundation.

DNR: Department of Natural Resources.

GIS: Geographic Information System.

NOAA: National Oceanic and Atmospheric Administration.

SAV: Submerged Aquatic Vegetation.

SDGs: Sustainable Development Goals.

Chapter 1: Uncovering the Problem

Introduction

The marine biome is essential to life on Earth. As the oceans cover more than 70% of the Earth's surface, marine species are integral to the survival and well-being of all living, including humans. The benefits can be grouped into ecological (oxygen production, water purification, temperature regulation, etc.) economic (food, aquaculture, recreation, etc.), social (tourism, transportation, etc.), and cultural.

For centuries, coastal civilizations have prospered and thrived thanks to their strategic geolocation near the water, which has enabled them to harness all the benefits of access to seas for various reasons such as trading purposes, security, and sustenance. Maritime access has often been the lifeblood of societies. For example, Venice's proximity to the northern Sea was ideal for maritime trade and subsequent economic development in the Middle Ages which led to a boom in commerce. Locally, Baltimore became an important maritime port in the 19th century due to its immediate adjacency with the Chesapeake Bay and the Atlantic Ocean, leading to intercontinental trades. Similarly, Native American tribes along the Chesapeake Bay grew in power partly for the same reason. These historical occurrences have proved a consistent pattern: the success of coastal settlements is contingent upon access to waterways. However, unlike certain Indigenous communities, who often sought and upheld harmony and respect for water, modern-era civilizations have struggled to maintain the same values.

The marine ecosystems, now faced with numerous challenges due to human activities, risk serious irreversible consequences unless humanity is able to intervene. Among the challenges, are marine debris which is a significant environmental threat. Perhaps, one of the most concerning aspects of marine debris is derelict fishing gear, which is responsible for a phenomenon known as "ghost fishing." Derelict fishing gear is defined by the National Oceanic and Atmospheric Administration as any discarded, lost, or abandoned, fishing gear in the marine environment.[1] This gear, including nets, lines, traps, and other equipment, is highly durable and very often made of materials that are not biodegradable such as synthetic materials and plastic. The impact of ghost fishing is quite severe on species such as blue crabs and lobsters. That is not to say other species are safe. It affects a wide range of species outside of the ones humans typically rely on for food and affects even predatory fish, from stingrays to seals and seabirds. Trapped animals often die from starvation, injury, predators, or simply exhaustion.

[1] "What Is Ghost Fishing?" n.d. Oceanservice.noaa.gov. https://oceanservice.noaa.gov/facts/ghostfishing.html.

Figure 1: Barracuda fish trapped in a derelict fishing net. (source: https://sdg.iisd.org)

Ghost fishing occurs as a result of derelict fishing gear. In other words, if ghost fishing is a viral infection, derelict fishing gear is the main virus or the culprit. It is important to note that derelict fishing gear can still harm marine life even without human intervention or long after the fact. They can remain active in the environment for years or even decades, causing significant damage to marine biodiversity, ecosystems, and fisheries. As marine ecosystems are being polluted by ghost fishing, its long-term impacts can compromise those who rely on it the most.

As an escalating global problem, ghost fishing has been exacerbated in recent decades with the advent of recreational boats and fishing activities. There have been documented accounts of declines in the aforementioned marine species populations, particularly those already threatened by overfishing, pollution, and climate change.[2]

[2] Gilman, E. "Biodegradable Fishing Gear: Part of the Solution to Ghost Fishing and Marine Pollution." Animal Conservation 19, no. 4 (2016): 320–21. https://doi.org/10.1111/acv.12298.

The phenomenon also has negative socio-economic consequences, including reduced fish and crab stocks, and damaged fishing equipment, which directly impact the fishing industry in general and individual fishers or anglers in particular. The cost of replacing these gears can amount to hundreds of dollars or even thousands for the sophisticated ones. However, recreational fishers are not the only ones to be impacted by this issue. In some localities, especially the coastal ones, fishing is regarded as a primary source of income and food, and ghost fishing undermines that sense of food security and financial stability.

Despite various efforts in other fields to reduce derelict fishing and mitigate its effects, there is quite a lack of literature that tackles this issue from an architectural or planning point of view. This paper intends to build on existing knowledge by proposing architectural solutions that directly target the problem of ghost fishing and provide a new framework for more case studies. Although the paper will address ways to reduce ghost fishing, it is not within its scope to provide a guide for preventing derelict fishing gear. That is, the paper is not necessarily intended to address preventive measures, but rather exploit potential curative and restorative opportunities and solutions that this issue may offer.

Relation to Architecture

Architecture has long been recognized as an interdisciplinary field. It has deep ties and a unique ability to collaborate with other fields to address the pressing challenges of our time. Among these fields are aquaculture, life sciences, engineering, and marine biology which are also relevant for this research. The interconnected approach provides for a comprehensive understanding of the problem and a pathway to innovative solutions. It is through this approach that I shall operate and address the issue at hand.

There are many ways that architecture can intervene in the context of marine conservation. In this research, I will focus on two key architectural interventions: the restoration of biodiversity in the Chesapeake Bay and the creation of an educational center that promotes public awareness through direct engagement. The two strategies can be achieved simultaneously due to being inherently interconnected. These strategies combined can contribute to better site management and educational outreach, therefore reducing the harmful impacts of derelict fishing gear on marine environments.

Site management in this context involves creating an infrastructure or safe haven specifically aimed at using nature to heal itself of debris and pollution. By establishing a designated wetland along coastal land or on water, the proposal will directly involve taking restorative actions. As for the educational component of the solution, tourists and enthusiasts alike will be invited to witness and take an active role in building and maintaining habitats for these marine species.

Chapter 2: Literature Review

Introduction

The Chesapeake Bay, recognized as one of the nation's largest estuaries, is a highly critical habitat for aquatic life as well as a supporter of several economic enterprises. However, the same aspects that make it economically significant and ecologically vital make it susceptible to several environmental threats. Among these, ghost fishing remains one of the most engaged and persistent of the challenges. Despite concerted efforts from governments and regional organizations, ghost fishing-induced environmental loss continues to be widespread, resulting in unplanned death of a wide range of marine life. Target and non-target organisms become entangled, and the accumulation of abandoned fishing equipment in the long term has become among the primary causes of degradation of significant habitats, including submerged aquatic vegetation and reef systems critical to biodiversity.

Both recreational and commercial fisheries are suffering decreased stock of fish and constant gear loss.[3] This literature review examines current knowledge regarding ghost fishing, with the Chesapeake Bay region used as an example. It contains three general sections, beginning with a discussion of current fishing laws and policy loopholes that allow ghost fishing to occur. Later sections evaluate the ecological impacts of ghost fishing and survey technological, ecological, and

[3] NOAA | NOS | OR&R Marine Debris Program, "Effects of Derelict Fishing Gear in the Chesapeake Bay Assessment Report," Effects of Derelict Fishing Gear in the Chesapeake Bay Assessment Report | Marine Debris Program, accessed October 20, 2024, https://marinedebris.noaa.gov/derelict-fishing-gear/effects-derelict-fishing-gear-chesapeake-bay-assessment-report.

architectural interventions in operation or under consideration. Special emphasis is placed upon rehabilitation of habitats and the involvement of people as crucial strategies for long-term recovery. Placing the Chesapeake Bay in an international context, this chapter offers a conceptual platform for addressing marine degradation elsewhere in the world where comparable ecological issues occur.

Figure 2: Retrieval of Crab pots from the water. Source: NOAA

Current Fishing Policies and Their Shortcomings

Although efforts have been made to control fishing activities and minimize their environmental impacts through policy, ghost fishing has not been explicitly considered by the majority of policies. Policies have generally been geared towards preventing overfishing through seasonal closures and catch limits, but the policies have not been directed at gear recovery, disposal, or the prolonged existence of abandoned fishing gear in the marine ecosystem.

In Chesapeake Bay, there have been various bodies, such as the Atlantic States Marine Fisheries Commission (ASMFC) and the Maryland Department of Natural Resources (DNR), that have tried to regulate fishing activities. These have mainly been directed towards promoting sustainable levels of commercially valued species like blue crabs, striped bass, and oysters. While these organizations have come up with policies for avoiding overfishing and maintaining biodiversity, the particular problem of ghost fishing is not addressed by their policie.[4]

A key issue is the lack of enforceable, mandatory lost gear recovery programs. In most places, fishers are requested, but not compelled, to retrieve lost gear. Voluntary programs remain in limited extent and not county or statewide in application. Certain equipment is particularly difficult to recover, either because it is small and easy to overlook, such as hooks, or because it is constructed of durable material that is designed to withstand harsh environments, such as crab pots and gillnets. The bigger ones of these types are more likely to become entangled in vegetation and remain underwater permanently. In the Chesapeake Bay alone,

[4] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.

thousands of crab pots are lost annually, and without necessary recovery, there is ongoing buildup of ghost gear on the ocean floor.[5]

Additionally, reporting and tracking lost gear is a tremendous hurdle. There are no laws in almost all jurisdictions or places, such as the Chesapeake Bay, that mandatorily demand reporting of lost gear. The fishermen are not necessarily obligated to report if they lose nets, pots, or other equipment, so it is hard to fully determine or measure the entire extent of the issue. Thus, with no good data or statistics on what percentage of lost gear is present over time, it is a mystery to estimate the scale of the problem. It also makes it impossible for the government to properly resource gear recovery or put in place effective measures on a national scale.[6]

Where incentives are involved, existing fishery policies are not strong enough to encourage the usage of biodegradable gear. Despite as much as biodegradable gear has been shown to mitigate the long-term effects of ghost fishing, its uptake remains low owing in part to expense and absence of general awareness. To add more fuel to the flame, most fishing regulations still permit the use of non-biodegradable substances. Fishermen and anglers are not eager to change to biodegradable substitutes since they question if they are effective and do not want to alter what has been traditionally done.[7] A few fishermen do not even recognize it as being an issue.

[5] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.
[6] Caitlin Frenkel et al., "Why, and Where, Is Commercial Fishing Gear Lost? A Global Review and Case Study of Pacific Canada," ScienceDirect, September 25, 2023, https://www.sciencedirect.com/science/article/abs/pii/S0025326X23009621.
[7] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

There is also an issue of poor coordination between the state, federal, and local governments in the implementation of policies towards lost gear and ghost fishing. According to one study, policies may vary from state to state or region to region and this variation results in the failure to implement them, then creates loopholes for fishers to practice some irresponsible behaviors because they might not be held responsible for lost gear.[8] There is a huge gap also between the policymakers and the interests of the fishing industry, and this has been another key element in the failure of the current policies. Most of the anglers and fishers, particularly recreational fishers, are not adequately informed about the environmental effect of ghost fishing, and some are not even familiar with the term. A change to a new policy context that promotes education and public awareness would be a long way in solving the issue. In the absence of more cooperation from the fishing industry, ghost fishing will not be curbed in the near future.[9]

In spite of these limitations, some attempts at dealing with ghost fishing by certain agencies have involved some significant steps in new programs. For example, the National Oceanic and Atmospheric Administration's (NOAA) Marine Debris Act authorizes the funding of projects that work to minimize marine debris.[10] However, one of the largest obstacles to these programs remains a shortage of sufficient funding

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[8] Benjamin Drakeford, Andy Forse, and Pierre Failler, "The Economic Impacts of Introducing Biodegradable Fishing Gear as a Ghost Fishing Mitigation in the English Channel Static Gear Fishery," ScienceDirect, May 16, 2023, https://www.sciencedirect.com/science/article/pii/S0025326X23003491?via%3Dihub.

[9] Ibid

[10] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

and resources. They also have no metrics that make it more difficult to understand the entire extent of the problem.[11]

In summary, although current fishing policies have achieved progress in reducing overfishing and promoting ecological awareness, they have largely failed to account for the systemic nature of ghost fishing. The lack of mandatory recovery measures, limited support for sustainable gear alternatives, and weak intergovernmental coordination have hindered efforts to resolve the issue comprehensively. Breaking these impasses will necessitate not just policy change but also a cultural transformation within the fishing industry as well as adjacent communities.

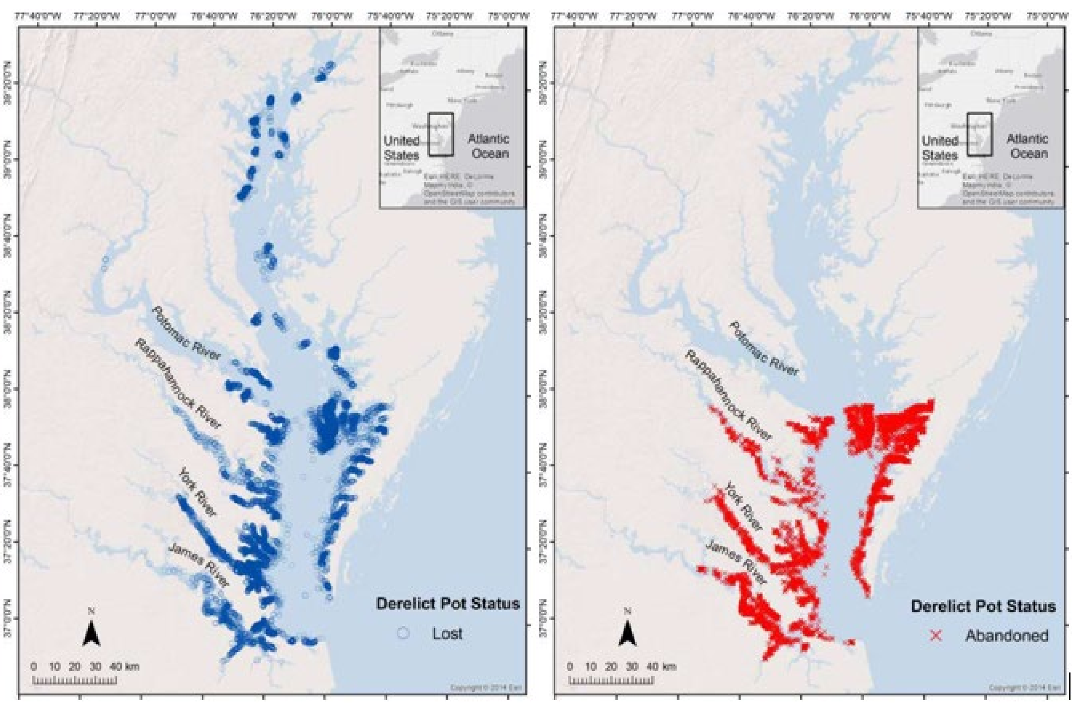

Figure 3: Lost vs Abandoned crab pots in the Chesapeake. Source: NOAA

[11] Ibid

Ecological Impact of Ghost Fishing on Marine Biodiversity

Ghost fishing remains accountable for a great deal of the deterioration of marine ecosystems worldwide, and the Chesapeake Bay is not any different. The impact of lost fishing gear on marine biodiversity has been found to be dismal. Lost gear in the Chesapeake Bay has been one of the leading causes of the blue crab's decline, as Bilkovic et al. has found. Blue crabs constitute a significant commercial food resource, both ecologically and economically.[12] They are one of the most economically valuable commercial food species in the Bay and bring in millions of dollars to the local economy every year. Ecologically, they are both predators and prey and play an essential role in the Bay's food chain.[13]

Once fishing gear is lost or abandoned, it keeps on catching sea creatures, and crab pots are typically the culprits. One study's estimate is that gear left behind in the Chesapeake Bay alone has the ability to trap more than 3.3 million blue crabs annually, which significantly affects the species and the balance of the whole ecosystem.[14] Since there is so high a rate of mortality,

[12] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.

[13] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.

[14] Benjamin Drakeford, Andy Forse, and Pierre Failler, "The Economic Impacts of Introducing Biodegradable Fishing Gear as a Ghost Fishing Mitigation in the English Channel Static Gear Fishery," ScienceDirect, May 16, 2023, https://www.sciencedirect.com/science/article/pii/S0025326X23003491?via%3Dihub.

blue crab populations decrease, already struck by overfishing, habitat loss, and water quality deterioration through pollution and contamination.

The environmental effects of ghost fishing cannot be understated. It goes beyond the economic value of these species captured. Even non-target species, such as seabirds, turtles, and marine mammals, are also commonly trapped by lost gear. These kinds of animals are what are normally termed "bycatch" and are trapped inadvertently by lost gear. The nature of the material from which the gear is constructed aggravates the situation. Man-made materials like nylon go into making the nets which are extremely slow to break down in water. Sometimes it takes decades for nylons to break down, meaning that the gear can persist in harming marine animals for as long as the material persists.[15]

As the lines and nets float along with the water, they also do additional damage by ripping up sensitive habitats like seagrass beds, salt marshes, and reefs.[16] The seagrass beds are especially significant in the Chesapeake Bay since they perform key ecosystem services like water filtration, carbon sequestration, and habitat for fish, crabs, and other aquatic creatures. Reefs, like oyster reefs, are also very valuable. They act as natural buffers that shield shores from erosion and provide habitat for numerous marine species.[17] When

[15] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.
[16] Andrew Altieri et al., "A Trophic Cascade Triggers Collapse of a Salt-Marsh Ecosystem with Intensive Recreational Fishing," JSTOR, accessed October 15, 2024, https://www.jstor.org/stable/23213769.
[17] Ibid

ghost fishing gear enters these habitats, it has the potential to reduce their contribution to the environment and their capacity to shelter other marine organisms.

Another research from the National Oceanic and Atmospheric Administration (NOAA) found that ghost fishing gear is speeding up the loss of underwater plants, like eelgrass and widgeon grass, which are crucial for many species in the Chesapeake Bay.[18] For example, blue crabs, for instance, utilize the vegetation for shelter and as a nursery for young crabs to mature. The degradation of these habitats from ghost fishing gear impacts not just individual species but the food chain at large, making it more difficult for the species that depend on these plants to exist.

The entanglement of larger marine animals is also a significant problem. Large sea mammals, sea turtles, and even large fish are not safe from this. For example, creatures like dolphins, seals, and whales can be victims of ghost fishing. Once predators, these creatures may find themselves as prey for other creatures. These animals can suffer injuries, starvation, or death due to their inability to free themselves from entanglement. In the Chesapeake Bay, species like the loggerhead sea turtle and certain species of fish are susceptible to these unintentional traps based on another study.[19] The loggerhead sea

[18] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.
[19] Donna Marie Bilkovic et al., "Ecological and Economic Effects of Derelict Fishing Gear In ...," ResearchGate, October 2016, https://marinedebris.noaa.gov/sites/default/files/publications-files/DFG_Effects_Chesapeake_Bay_Final_Report_2016.pdf.

turtles, which are already deemed a threatened species by the Endangered Species Act, are susceptible to further population reduction due to ghost fishing gear.[20]

When it comes to economic consequences, the commercial fishing industry, which relies heavily on healthy fish and crab populations, suffers the most when derelict gear continues to deplete these populations. As estimated, ghost fishing in the Bay can cause a loss of millions of dollars annually in crab revenues alone.[21] Fishers must also replace gear that is lost. Although on a personal level it may appear trivial, the expense is rather great based on the equipment type and how often loss occurs.

For recreational fishing, also a significant economic generator in the Chesapeake Bay area, is impacted by ghost fishing too. Recreational anglers tend to fish for species like striped bass and bluefish. When ghost fishing destroys habitats, it cuts down on the ability of recreational anglers to fish for these species which could further result in decreased tourism.[22] This situation needs to be addressed differently. Past measures to counter ghost fishing have been based both on prevention and mitigation. Prevention measures that have been put in place include encouraging fishers to use more degradable

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[20] Donna Marie Bilkovic et al., "Ecological and Economic Effects of Derelict Fishing Gear In ...," ResearchGate, October 2016, https://marinedebris.noaa.gov/sites/default/files/publications-files/DFG_Effects_Chesapeake_Bay_Final_Report_2016.pdf.
[21] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.
[22] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.

equipment that will degrade faster in the water, thus reducing the amount of time the gear remains functional. A good example is degradable crab pots that are designed to collapse after a period of time and not to continue trapping marine life for years on end.[23]

Mitigation efforts, however, are the processes of derelict gear removal from water so that it does not cause further damage. In Virginia, the state has had a gear removal program under the Virginia Marine Debris Reduction Program that has successfully removed thousands of derelict crab pots and nets in the Chesapeake Bay as seen in one article. Such activities not only mitigate the direct effect of ghost fishing, they also yield useful data on where and what type of gear is most likely to be lost. This can be utilized to map out future prevention strategies, such as in identifying high-risk areas where fishers are most apt to lose gear.[24]

In conclusion, ghost fishing remains a serious menace to marine life in the Chesapeake Bay and globally. It impacts valuable species, target species, and non-target species. Prevention and reduction measures of ghost fishing are underway, yet there is a need to do more to eliminate the root causes of the issue and to restore the derelict gear's impacted habitat.

[23] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.

[24] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

Current Solutions and Technological Interventions

Several policy and technology-based solutions have been suggested and adopted to reduce the impacts of ghost fishing. One of the most practical of these is the development of biodegradable fishing nets. They are meant to degrade more quickly in the sea. While ordinary fishing nets such as those made of plastics and nylon degrade in decades in the sea, biodegradable ones provide an improvement. Materials produced from natural fibers or other biodegradable substances break down quicker and more efficiently.[25]

Biodegradable equipment holds a future that is encouraging in ghost fishing prevention but still has some major drawbacks. Durability is one of the main concerns of biodegradable gear. Fishermen are accustomed to their equipment paying for their livelihood. They may not be willing to utilize biodegradable gear as it has such a short life. Conventional gear is meant to be solid and long-lasting. They are resistant to harsh conditions and can be recycled. Biodegradable materials, by their very definition, are designed to break down rapidly. Their lack of longevity is a significant problem in relation to conventional gear.[26] That said, there have been some engineering advances over the past few years that have allowed for the development of sustainable materials that can perform as well as conventional gear without compromising its integrity. There has been some research conducted that has demonstrated

[25] James DelBene, Andrew Scheld, and Donna Bilkovic, "Preferences for Derelict Gear Mitigation Strategies by Commercial Fishers," Marine Policy, July 3, 2021, https://www.sciencedirect.com/science/article/abs/pii/S0308597X21002736?via%3Dihub.
[26] Ibid

that such materials possess the durability to carry out their purpose and yet biodegrade within a reasonable period of time.[27] Another obstacle to the utilization of biodegradable equipment is cost. Although eco-friendly products are gaining popularity, they tend to be more costly than conventional equipment. This added cost is a huge hurdle, especially for smaller-scale fishermen who may not have the economic means to replace gear frequently. Other than the development of biodegradable gear, technology continues to see the light.

Some of the other technologies that retrieval software uses are the side-scan sonar and "Autonomous Underwater Vehicles" (AUVs) to accurately map the seafloor or ocean bottom and retrieve derelict gear and other debris.[28] Side-scan sonar works by sending out sound waves that reflect off objects at the seabed which produces detailed images that can be used to spot debris.[29] AUVs, however, are typically unmanned. These are underwater

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[27] Benjamin Drakeford, Andy Forse, and Pierre Failler, "The Economic Impacts of Introducing Biodegradable Fishing Gear as a Ghost Fishing Mitigation in the English Channel Static Gear Fishery," ScienceDirect, May 16, 2023, https://www.sciencedirect.com/science/article/pii/S0025326X23003491?via%3Dihub.

[28] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

[29] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

devices that have sensors and cameras and can be used to retrieve equipment left behind in the deep ocean where it is difficult to access by other means.[30]

These recovery efforts, however, were very successful, according to a study conducted by the National Fish and Wildlife Foundation; they were able to recover thousands of ghost pots every year.[31] It has benefited the sea creatures in the area by lessening the number of traps and nets that still catch animals years after they are lost. Gear recovery programs are not just valuable to marine life but also as a data gathering mechanism, somewhat similar to a record database that assists researchers in comprehension of the trends of gear loss and can inform us about where and in what ways fishing gear is most likely to be lost. This information is essential in guiding future prevention measures and in ensuring that recovery efforts are directed at high-risk and vulnerable areas.[32]

Government efforts have also been at the center of the fight against ghost fishing.

Initiatives such as the Derelict Crab Pot Recovery Program encourage fishermen to report lost gear and become involved in coordinated clean-up

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[30] Immacolata Liotta et al., "Mitigation Approach of Plastic and Microplastic Pollution through Recycling of Fishing Nets at the End of Life," ScienceDirect, December 15, 2023, https://www.sciencedirect.com/science/article/pii/S0957582023011412?via%3Dihub.

[31] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

[32] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

efforts.[33]] These programs typically offer monetary compensation or other incentives to fishermen who help retrieve derelict gear from the water. Besides the physical removal of derelict gear, these types of programs serve as educational forums that heighten awareness of the environmental problem of ghost fishing.

Despite the success of these sorts of programs, the very number of equipment lost each year and the limited availability of funding render complete resolution impossible. What the future holds is unclear. Therefore, demand remains on the rise for yet more innovative methods of prevention as well as mitigation.

The Role of Architecture in Addressing Ghost Fishing

Architecture provides a special chance to mitigate ghost fishing. Architects design sanctuaries for humans and refuges for animals. However, architects' roles do not stop there. Habitat restoration, revitalization of waterfront cities, and public education are among the possibilities this profession can provide. Although architecture is not typically connected to marine conservation, it may be employed to aid in the solution of ecological problems, and in this instance, ghost fishing ones. Through the incorporation

[33] Caitlin Frenkel et al., "Why, and Where, Is Commercial Fishing Gear Lost? A Global Review and Case Study of Pacific Canada," ScienceDirect, September 25, 2023, https://www.sciencedirect.com/science/article/abs/pii/S0025326X23009621.

of an architectural intervention in this environmental issue, architecture can emerge as a healing force to provide physical, educational, and social interventions to mitigate the impacts of ghost fishing and bring more harmony between human society and marine biome.

Figure 4: Oyster-tecture by SCAPE. Source: SCAPE

One of the greatest values that architecture can contribute is through a reparative design approach in direct service to marine ecosystems. For example, artificial reefs or created wetlands can serve as natural buffers to debris loads, such as in the Oyster-tecture project by SCAPE landscape architecture firm(figure 03). Although the project mainly aimed at reducing ghost fishing, it also serves as a barrier to stop ghost gear from inflicting more damage but also assists in ecosystem restoration by providing habitats for other organisms.

An article stated that artificial reefs made from local materials such as oyster shells in Chesapeake Bay have been found to increase biodiversity as they give hard surfaces for oysters and other organisms to settle upon.[34]

Another solution that is architecture-based is wetland restoration. Wetlands are significant breeding and feeding areas for several marine animals, including fish and crustaceans. The National Harbor wetland in Baltimore is home to the blue crab, reptiles, and birds. Restoration of these areas with the help of architectural solutions can minimize the chances of species getting entangled in discarded gear. It provides them with more guarded and secure habitats. Moreover, wetlands also function as natural filters for pollutants that work to improve water quality.[35]

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[34] Donna Marie Bilkovic et al., "Ecological and Economic Effects of Derelict Fishing Gear In ...," ResearchGate, October 2016, https://marinedebris.noaa.gov/sites/default/files/publications-files/DFG_Effects_Chesapeake_Bay_Final_Report_2016.pdf.

[35] Caitlin Frenkel et al., "Why, and Where, Is Commercial Fishing Gear Lost? A Global Review and Case Study of Pacific Canada," ScienceDirect, September 25, 2023, https://www.sciencedirect.com/science/article/abs/pii/S0025326X23009621.

Figure 5: Wetland at the National Harbor, Baltimore. Source: Ayers Saint Gross.

There is another architectural remedy for ghost fishing: the development of living shorelines along the waterfront. It is a green strategy that uses natural vegetation and structures to stabilize coasts. Living shorelines aim to avert erosion and create habitat for both marine and upland life.[36] Such green infrastructures safeguard vulnerable ecosystems from those flooding trash and ghost gear.

In addition to habitat restoration, architecture can also serve a significant purpose in public education and engagement with the issue of ghost fishing. Educational waterfront centers, such as the CBF Brock Center, can function as research, conservation, and public engagement centers. These

[36] Donna Marie Bilkovic et al., "Ecological and Economic Effects of Derelict Fishing Gear In ...," ResearchGate, October 2016, https://marinedebris.noaa.gov/sites/default/files/publications-files/DFG_Effects_Chesapeake_Bay_Final_Report_2016.pdf.

centers can serve a basic function in making individuals increasingly aware of the detrimental effects of ghost fishing and allow the public to engage.[37]

Lastly, interactive exhibits in these education centers can show the effect of ghost fishing on local species and habitats. From existing data and visualization, representations can be designed to describe the degree and seriousness of the issue. For example, interactive installations such as 4D theater can simulate the underwater environment so that visitors can experience how marine life becomes entangled in derelict gear. Additionally, these facilities can have hands-on activities such as clean-up exercises, workshops, and gear recovery demonstrations. This will enable visitors to become actively involved in the conservation process.[38] These built spaces can be used as shared spaces where researchers, scholars, and the public at large can meet and come up with innovative solutions to ghost fishing. It can promote engagement with local communities and fishermen, all in efforts to encourage sustainable practices, such as reducing the use of non-biodegradable fishing gear and participating in programs aimed at retrieving lost gear from the water. Public involvement in ghost fishing solutions.

Some of the solutions discussed in the texts are the construction of green fishing ports, marinas, and waterfront developments. These structures

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[37] Benjamin Drakeford, Andy Forse, and Pierre Failler, "The Economic Impacts of Introducing Biodegradable Fishing Gear as a Ghost Fishing Mitigation in the English Channel Static Gear Fishery," ScienceDirect, May 16, 2023, https://www.sciencedirect.com/science/article/pii/S0025326X23003491?via%3Dihub.

[38] Ibid

do not allow ghost gear to enter sensitive habitats. Waterfront developments can also be constructed in such a way that they incorporate marine debris monitoring systems, which notify local authorities of locations where ghost gear has been spotted and allow them to launch clean-up operations.[39]

All in all, the combination of some of the technologies above with architecture can build more efficient and integrated solutions to ghost fishing. This lends itself to the idea of floating platforms. Floating platforms, as unusual and unpopular as they are, present an interesting solution to this issue. These structures would have double purposes: preventing ghost gear from drifting into susceptible ecosystems and acting as data centers to track the movement of oceanic debris. This kind of architectural intervention will have the direct impact of curtailing ghost fishing and aiding research for more sustainable means of fishing.[40]

Evidently the inclusion of architecture in the marine conservation programme will result in innovative solutions as a by-product of an interdisciplinary process. Combining architecture, environmental science, landscape, and marine biology to develop integrated solutions is the secret to success in addressing the issue of ghost fishing. Policy-maker and local

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[39] Immacolata Liotta et al., "Mitigation Approach of Plastic and Microplastic Pollution through Recycling of Fishing Nets at the End of Life," ScienceDirect, December 15, 2023, https://www.sciencedirect.com/science/article/pii/S0957582023011412?via%3Dihub.

[40] Immacolata Liotta et al., "Mitigation Approach of Plastic and Microplastic Pollution through Recycling of Fishing Nets at the End of Life," ScienceDirect, December 15, 2023, https://www.sciencedirect.com/science/article/pii/S0957582023011412?via%3Dihub.

fisherman collaboration can enlighten the underlying causes of ghost fishing. Through habitat restoration, public education, and sustainable infrastructure design, architecture can make the human and marine environment coexist more sustainably.[41][42]

Habitat restoration is just one of numerous solutions to reducing the impacts of ghost fishing, especially in delicate ecosystems such as the Chesapeake Bay. The Bay itself has endured ecological stress from pollution, overfishing, habitat loss, and compounding impacts of climate change for decades. Ghost fishing compounds these problems by placing extra pressure on ocean wildlife and the ecosystems they depend on to survive. The dumping of used fishing equipment results in biodiversity loss and habitat degradation. Nevertheless, habitat restoration initiatives offer a way to undo some of these damages and allow the marine ecosystem to recolonize.

As an example, one of the most successful habitat restoration activities in the Chesapeake Bay has been the reestablishment of oyster reefs. Oyster reefs are an important component of the ecological balance of the Bay, as we remember that oysters are naturally occurring water filters that help to eliminate pollutants and excess nutrients from the water column, hence

[41] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.
[42] Donna Marie Bilkovic et al., "Ecological and Economic Effects of Derelict Fishing Gear In ...," ResearchGate, October 2016, https://marinedebris.noaa.gov/sites/default/files/publications-files/DFG_Effects_Chesapeake_Bay_Final_Report_2016.pdf.

enhancing the quality of water. On top of their filtering advantages, oyster reefs also serve as habitat and nursery areas for numerous marine species, such as fish, crabs, and other invertebrates. They simply cannot survive without oysters. These reefs are the type of "living infrastructure" that underpins biodiversity and renders the Bay's ecosystems more resilient.[43]

Disease and habitat loss have led to a drastic oyster depletion in the Bay over the last century especially in recent years. Restoration activities led by groups like the Chesapeake Bay Foundation have, however, attempted to stem the tide. The projects entail the construction of artificial reefs using materials like oyster shells, limestone, and other substrates on which oyster larvae can attach and grow. By rebuilding oyster reefs, the Bay becomes more capable of sustaining marine life, thus making the shoreline less vulnerable to ghost fishing. For instance, when oyster reefs are rebuilt, the biodiversity achieved and improved water quality can decrease the amount of species trapped unintentionally in ghost gear.[44]

Besides the restoration of oyster reefs, seagrass bed restoration is another vital habitat restoration activity in Chesapeake Bay. Seagrass beds such as eelgrass provide nurseries for juvenile fishes. They are a vital part of

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[43] Donna Marie Bilkovic et al., “Ecological and Economic Effects of Derelict Fishing Gear In ...,” ResearchGate, October 2016, https://marinedebris.noaa.gov/sites/default/files/publications-files/DFG_Effects_Chesapeake_Bay_Final_Report_2016.pdf.

[44] Jianing Luo et al., “Uncovering the Relationship between Floating Marine Litter and Human Activities in Watersheds,” ScienceDirect, December 14, 2023, https://www.sciencedirect.com/science/article/pii/S0025326X23013280?via%3Dihub.

the ecosystem, stabilize sediments, resist erosion, and enhance water quality by absorbing nutrients and filtering pollutants.[45] Similar to oyster reefs, seagrass beds also provide important foraging and breeding habitats for numerous species impacted by ghost fishing.[46]

Like oysters, seagrass beds are also very susceptible to derelict fishing gear damage, since nets and lines get tangled in the vegetation. Gear can shade them out of sunlight. This contributes to habitat loss and further diminishes the Bay's ecosystem to operate as a whole. Chesapeake Bay seagrass restoration endeavors work to replant and revive these crucial ecosystems and reestablish the submerged aquatic vegetation that provides nurseries for blue crabs and turtles, among many others.

In conclusion, these ecological and architectural interventions show the possibility of even more solutions that not only counter the immediate effects of ghost fishing but also assist in the long-term restoration of biodiversity. Through the adoption of habitat restoration and eco-friendly architecture designs, the ecosystems of the Chesapeake Bay begin to heal from the pressure of ghost fishing and other environmental issues. The Chesapeake Bay case study is a model for other bodies of water globally.

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[45] Eric Gilman, "Status of International Monitoring and Management of Abandoned, Lost and Discarded Fishing Gear and Ghost Fishing," ScienceDirect, July 14, 2015, https://www.sciencedirect.com/science/article/abs/pii/S0308597X1500175X?via%3Dihub.

[46] Ibid

Chapter 3: Methodology

Sources Selection

Throughout the selection of the sources, the University of Maryland online library was used as the main database for research and findings. Apart from the University of Maryland Library, Science Direct as well as JSTOR was also used for additional details. The same set of keywords and identical search terms employed in conducting the initial search in every database was utilized: "Ghost fishing", "derelict gear", and "fishing gear AND Chesapeake Bay". The scope of the search was limited to articles published after 2000, in full text, in the English language, and in scholarly journals. With the keywords of the University of Maryland Library, 2,064 articles were initially retrieved.

For the selection of sources, the University of Maryland online library was used as the primary database for research and findings. In addition to the University of Maryland Library, Science Direct and JSTOR were also consulted for further information. The following keywords and similar search term combinations in the initial search in each database were used: “ghost fishing”, “derelict gear”, and “fishing gear AND Chesapeake Bay”. The search was restricted to publications made after 2000, available in full text, written in English, and published in academic journals. Using the keywords from the University of Maryland Library, 2,064 publications were initially retrieved.

Keywords Combination	UMD Online Library	Science Direct	JSTOR
Ghost fishing	208	1,315	541
Derelict gear	160	256	268
Fishing gear AND Chesapeake Bay	65	243	543

Table 1: Terms used for search and numbers of entries found.

In order to further reduce the search from all three databases, papers were filtered by reading title and keywords. Abstracts were read in a few cases to gain a sense of the summary of the paper. A cut off was placed at 59 publications. This is worth noting as having been completed over the course of several weeks. Papers were chosen based on at least two of the following:

1. The research topic addressed the relationship between derelict fishing and species that are harmed by this phenomenon;
2. The paper explored the problem in-depth;
3. The paper contains a rich amount of data and graphs.

4. The research is not restricted to a specific part of the world except the Chesapeake Bay;

5. The research offers some insight into solutions to the problem or alternative sustainable materials.

Upon closer examination, 8 papers were eliminated on grounds explained in the following section. The final candidates included 5 papers from JSTOR, 2 from Science Direct, and 37 from the University of Maryland Library that would be utilized for systemic review, synthesis, and conclusion drawing that would be in line with our goal in this research. Other than these sources, one paper was taken from an open European source known as Zenodo. One source was from Yale Online Magazine Yale Environment 360. Other sources used are BBC, Zoological Society of London, and Proquest. From each of these sources, one paper was utilized. Finally, 2 sources were from the National Oceanic and Atmospheric Administration.

Summary of 40 Journals

Although the research criteria were limited to articles published in the last 24 years, two articles prior to 2000 were deemed necessary due to their relevance to the topic, and therefore selected later on. One was from 1982 and the other from 1983. Since all of the rest were restricted to papers published after 2000, most of the research is recent within the same century. Out of the

40 finalist articles selected, 18 articles were published in the most recent decade (2020-present). While writing the literature review, 6 papers were excluded from the finalists due to irrelevance to the topic. 2 papers were inaccessible due to permissions or site issues. The rest were selected for the best match and relevant information.

Most literature focused on the wider context of ghost fishing. In regards to academic disciplines, the 40 journals span various academic areas that can be classified into the following categories: 11 articles were from Marine Science, 4 articles from Environmental studies, 3 articles from Biology, 2 articles from each technology, engineering, and fisheries science, 1 article from each conservation biology, business, agriculture, ecology, marine engineering, Bioscience, and Natural sciences. There were a total of 6 articles without a clear discipline denotation, thus categorized as non-applicable or N/A.

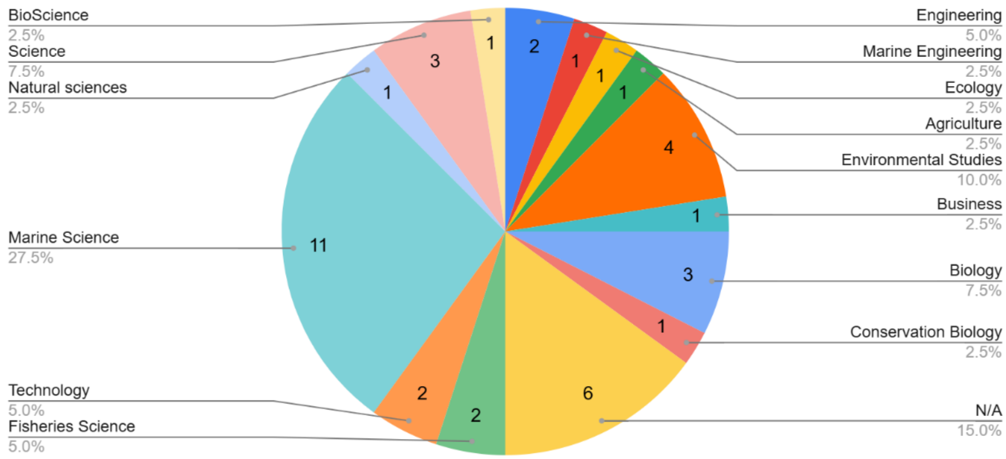

Illustration 1: Categories of Disciplines Involved in the Research.

Summary of findings:

Ghost fishing has been a persistent problem in a wide range of areas, emphasizing the multifaceted environmental and economic consequences of lost, abandoned, and discarded fishing gear (ALDFG). The existing body of literature defines the problem with quantitative data to some extent. Many studies emphasize the urgent need for interventions, either through regulation or through efforts to raise public awareness of ghost fishing's impact on marine life. However, the synergy between a call for action and what these actions are leaves much to be desired.

A number of literature has also addressed the difficulties in achieving and enforcing regulations and policies in place. The limited availability of public resources has also been listed as one of the factors leading to derelict fishing gear. Challenges range from a lack of coordination between jurisdictions in international waters to limited coordination among federal and environmental organizations. These barriers indicate a need for collaborative solutions that combine policy measures with community center initiatives.

In conclusion, these articles were very useful in composing a literature review in the previous chapter that offers a comprehensive overview of the problem and potential solutions and opportunities available. It is an important step toward mitigating the negative impact of derelict fishing and ghost fishing overall.

Methodology for Site Selection:

Moving forward the site selection methodology will be a three-pronged analysis that takes into account the ecological aspect, species impacted behavioral patterns, and sea level rise forecast. Ecological factors may be essential to the species most vulnerable to ghost fishing impacts. The selection will be inspired by the species identified in the research. Some species are more vulnerable to this problem than others in this region of the world Certain species are more susceptible to this issue than others in this part of the world.

Two species in particular that have been mentioned several times in the findings are blue crabs and oysters. The two key species were discussed throughout the findings for their ecological and economic significance in the region.

Blue crab and oyster life cycles, mortality, habitat location, and behavior patterns will be a first-order selection criterion. Secondly, areas with a high level of ghost fishing gear buildup, which have been determined by the National Oceanic and Atmospheric Administration, will be a second required selection criterion. NOAA carries maps characterizing these affected areas. They also yield valuable data that identifies hotspots of ghost fishing activity. By combining this data with blue crab and oyster habitat maps, site selection can directly address areas where ghost fishing is having the greatest ecological impact.

Lastly, sea level rise and climate change scenarios will also be taken into consideration in site selection. Temperature increase and sea level change are expected to affect marine ecosystems in the near future. Elevated temperatures could affect species' growth and survival, while sea level rise could redraw coastal ecosystem map. In general, keeping this in consideration will enable adaptive solutions that adjust to both current and future environmental contexts even under the scenario of altering environmental conditions.

Chapter 4: Precedent Studies

Introduction

Understanding the precedent studies is an important step in making informed decisions about the proposed thesis. This chapter examines five selected projects: the Harbor Wetland at the National Aquarium, Oyster-tecture, the Floating Kayak Club, the Makoko Floating School, and the Sydney Opera House. Each of the projects was selected due to its innovative way of combining architecture in aquatic-based ecosystems. They also deal with the ecological and site-specific contexts in different ways. The selected projects comprise a broad range of scales, geographies, and cultural contexts. They also offer an interesting intersection of water and architecture. Examining so diverse a set of precedents helps to extract principles that guide innovative approaches to designing adaptive and resilient waterfront architecture.

All of these projects examine water not as a passive backdrop but as an active element of the design in some way, whether by growing marine life, responding to changing tides, or enabling public engagement with the water. The Harbor Wetland, for example, is an urban wildlife habitat while the Oyster-tecture shows the part played by biophilic design in reviving marine life. Conversely, Floating Kayak Club and Makoko Floating School are instances of floating architecture that are responsive to environmental context and community requirements in a dynamic manner. Finally, the Sydney Opera

House, though more symbolic, embodies the cultural possibility of waterfront architecture and its potential to advance community identity.

Overall, the aim of this chapter is to communicate not just the technical and programmatic interventions utilized but also the underlying reasons why these projects are successful and sustainable. It is a platform for developing designs that not just facilitate biodiversity but also raise public awareness and promote contact with aquatic environments.

Case Study 1: Harbor Wetland at the National Aquarium in Baltimore by Ayers Saint Gross.

Illustration 2: Site plan of the Harbor Wetland at the National Aquarium.

The Harbor Wetland of the National Aquarium is situated in Baltimore, Maryland.

Conceived by Ayers Saint Gross in association with Studio Gang, Biohabitats, and McLaren Engineers, is an ambitious attempt to restore urban ecology through design. Within the newly renovated area of Baltimore's Inner Harbor, this 10,000-square-foot floating wetland was modeled after the salt marsh ecosystems that once bordered the edges of the Chesapeake Bay.[47] The prototype incorporates over 32,000 native marsh grasses and shrubs, which are planted on mats made from recycled plastic.[48]

The wetland design carefully considers the needs of various species. The habitat is visited by fish, birds, invertebrates, and crustaceans as discussed in one article.[49] It is densely vegetated and provides a refuge and feeding ground for urban wildlife. It is a verdant microhabitat within the urban environment. Furthermore, the root systems of the vegetation act as natural filters. They ensnare pollutants and enhance water quality surrounding the wetland. This role is particularly crucial in the Inner Harbor of Baltimore, particularly considering that it has been repeatedly regarded as an area that has long endured water quality problems due to industrial pollution.

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[47] "Harbor Wetland," National Aquarium, accessed October 31, 2024, https://aqua.org/explore/exhibits/harbor-wetland.
[48] Ibid
[49] Ibid

Aside from its environmental role, the Harbor Wetland also serves as an educational platform. It supplements the general mission of the National Aquarium to raise environmental awareness. The wetland provides volunteers and visitors with a hands-on learning experience of wetland ecosystems and allows them to interact with its habitats.

Reflecting on this precedent, there are several new ways in which this thesis can be approached. The Harbor Wetland also has an innovative aeration system that simulates natural tidal action, providing a vital element to support healthy wetland ecosystems.[3] This gives an idea of the stringent requirements of a wetland. Tidal action impacts numerous marine organisms. For example, turtles rely on this for migration. As the harbor is so far within the Chesapeake Bay, this kind of movement would be hard to naturally replicate. This example illustrates how human beings can utilize the power of engineering to help marine animals by replicating other natural phenomena.

Case Study 2: Oyster-tecture by SCAPE Landscape Architecture.

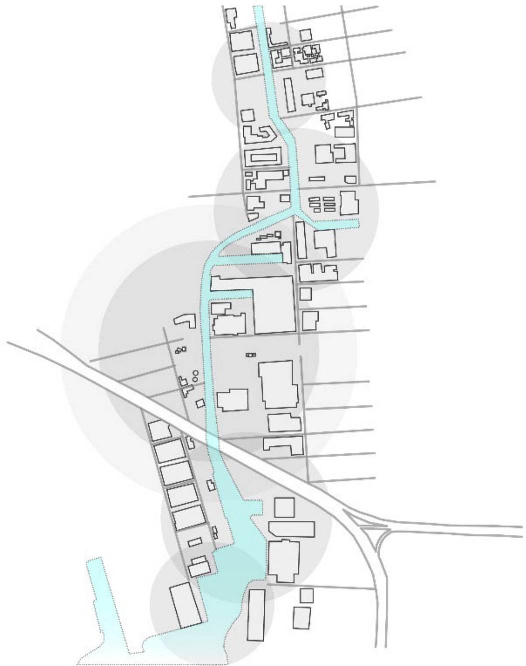

Illustration 3: Gowanus Canal, NY. The site of the Oyster-tecture .

Oyster-tecture, developed by SCAPE Landscape Architecture, is one such example of introducing ecological restoration in cities. It was conceived as a "living infrastructure" project. Oyster-tecture makes use of oyster reefs to reclaim and re-design New York City's polluted waterways, such as the Gowanus Canal and New York Harbor The design consists of subaquatic structures made of fuzzy rope mesh, used as a substrate for the settlement and growth of oyster larvae (spat).[5] The larvae grow into oysters and create complex reefs over time, generating a variety of environmental benefits.[50]

[50] "Oyster-Tecture," SCAPE, January 31, 2024, https://www.scapestudio.com/projects/oyster-tecture/.

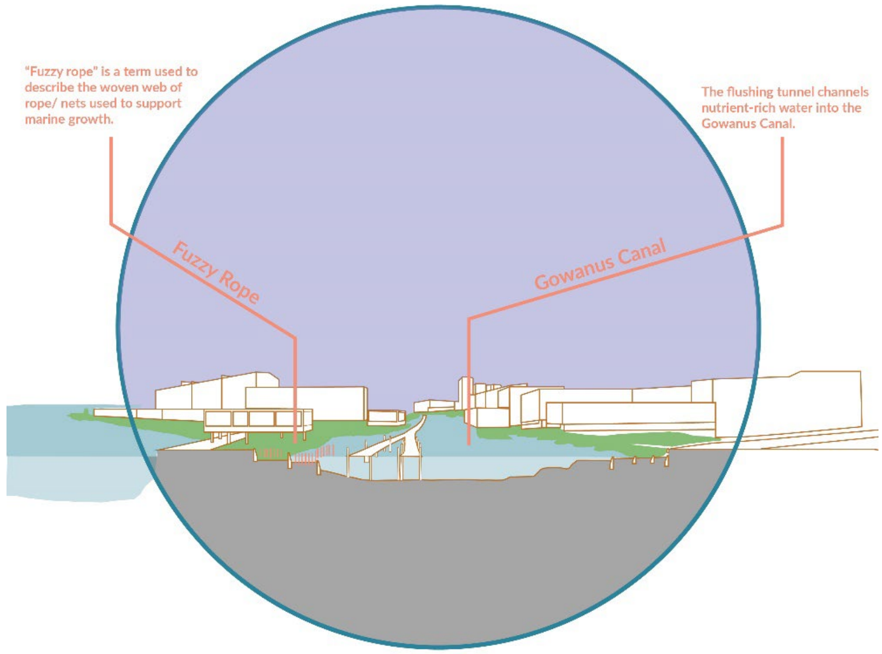

Illustration 4: Cross section of the Gowanus Canal and Oyster-Tecture project.

The primary role of oyster reefs is their natural water filtration ability. One oyster has the ability to filter as much as 50 gallons of water in a single day and remove pollutants, sediment, and excess nutrients from the water.[51] Through this heavy filtering, the water quality can be improved. It also creates healthier aquatic habitats in New York waterways. The idea of oyster-tecture emphasizes the environmental potential of these reefs since they are natural distributed filtration systems that filter urban waters in an environmentally friendly and low-energy-demand way. This process of

[51] "Oyster Fact Sheet," Chesapeake Bay Foundation, accessed October 31, 2024, https://www.cbf.org/about-the-bay/chesapeake-wildlife/eastern-oysters/oyster-fact-sheet.html#:~:text=An%20adult%20oyster%20can%20filter,where%20they%20are%20not%20harmful.

natural filtration is an inexpensive method relative to traditional water filtration systems that require energy It acts as a model for city resilience.[52]

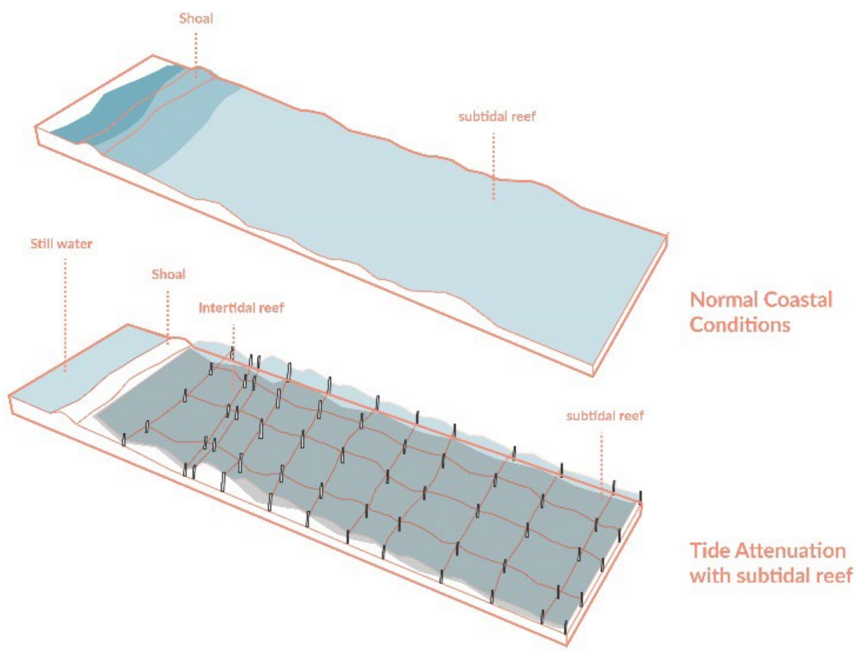

Illustration 5: Illustration of how oyster reef can attenuate coastal tides.

Apart from water purification, the oyster reefs also play a significant role in shoreline stabilization and coastal resilience. The density of the reefs regulates wave intensity and reduces the impact of waves on the coast and erosion levels. This is particularly applicable in the scenario of climate change with rising sea levels and increased storm surges posing a greater danger to coastal cities like New York. The reefs act as a natural water breaker. They

[52] Kate Orff and Jeffrey Sachs, *Toward an Urban Ecology: Scape* (New York: The Monacelli Press, 2016).

also offer a "soft" infrastructure option to conventional hard retaining walls, which are not just expensive to construct but are also less sustainable.[53]

The success of the project attests to the potential for biomimicry and ecosystem-based technology to be applied to the challenges of urban environmental problems using landscape and building design.

The strategy of this precedent, utilizing oysters as bio-engineers, aligns with the thesis research on restorative design principles that work in tandem with natural processes to improve the degraded environment that is the result of a man-made problem. The project demonstrates how architecture can extend beyond the built structure to take up the challenge to design functional ecosystems that contribute positively to urban resilience. It is an example of an innovative design approach that is both resilient and regenerative.

Case Study 3: Floating Kayak Club in Copenhagen by Force4 Architects.

[53] Kate Orff and Jeffrey Sachs, *Toward an Urban Ecology: Scape* (New York: The Monacelli Press, 2016).

Illustration 6: Site plan of the Floating Kayak Club.

Force4 Architects' design for the Copenhagen Floating Kayak Club is another creative solution for flexible and sustainable floating architecture. Located in the city harbor, the project creates a specialized area for kayakers. While minimalistic in form, it is open and provides a bird's-eye view of the harbor, inviting kayakers and users to be interactive with the water on a personal level. the design integrates itself into its natural environment by somehow keeping a low profile and inconspicuous footprint.[54]

Constructed with eco-friendly materials, the Floating Kayak Club proves that going green can be achieved even in floating structures.[55] Its base, which rises and falls with the tide, ensures flexibility in the context of fluctuating water levels. It is a considerable challenge for waterfront development considering its position as well. This flexibility is important in the sense that it enables the club to accommodate different tidal patterns and seasonal fluctuations in water level without affecting the ecosystem of the harbor.

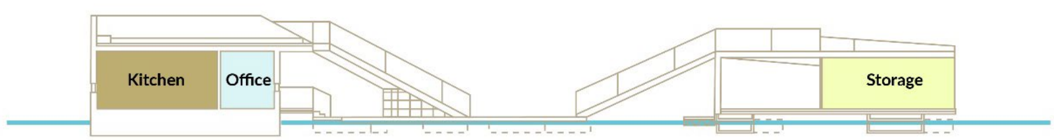

Illustration 7: Program zone.

Perhaps, one of its most distinctive features is its connection to the water, which goes beyond functional access. It is an experiential aspect that engages people with the water even before actually kayaking. The open and

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[54] "Den Flydende Kajakklub," Force4, accessed October 31, 2024, http://force4.dk/projects/kayak-vejle/.
[55] "Den Flydende Kajakklub," Force4, accessed October 31, 2024, http://force4.dk/projects/kayak-vejle/.

broad sides of the structure provide unobstructed views of the water landscape. This aspect helps in the immersion in the environment for the users.

This case study responds to the particular requirements of its situation. It demonstrates that form need not always serve function, but can also serve beauty. Environmentally, the Kayak Club demonstrates the potential for floating architecture to enable recreational activities in a way that is not intrusive to its environment. This case study informs the thesis investigation of adaptability., It was designed with climate change in mind by allowing the building to float freely even in situations of severe storms.

Case Study 4: Makoko Floating School in Lagos by NLÉ.

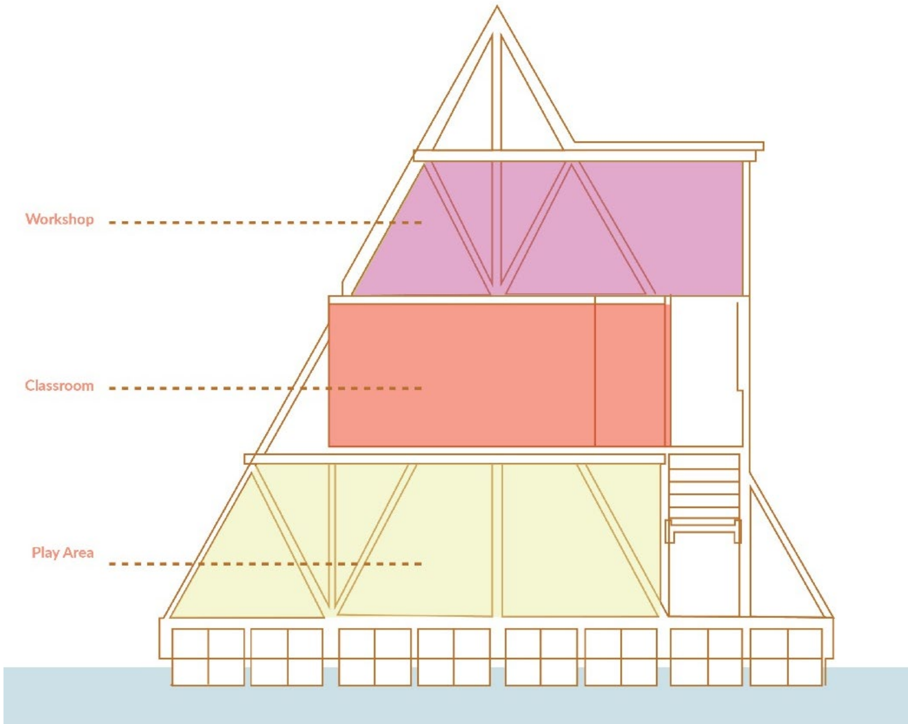

Illustration 8: Cross Section of the Makoko School project.

NLÉ's Makoko Floating School, led by architect Kunlé Adeyemi, was an experimental structure that dealt with urgent environmental and social challenges facing Makoko. Makoko is a Lagos informal water settlement in Nigeria, surrounded by water. The school was designed as a model of an efficient and green building that serves as a learning center for the children of fishermen on different subjects.[56] The coastal areas of Lagos are generally susceptible to sea level rise and flooding. Constructed on a triangular A-frame foundation, the school is floating on recycled plastic barrels that are buoyant

[56] "MFS I – Makoko Floating School: Lagos, Nigeria: 2011," NLE, accessed October 31, 2024, http://nleworks.com/case/makoko-floating-school/.

and enable the structure to adjust to rising water levels.[57] This construction rendered the school resistant to flooding during seasonal flooding, a significant factor in the flood-prone Lagos Lagoon environment.[58]

The three-story building was intended to fulfill a number of community functions. The ground floor has an open playground area, the second floor has a series of four enclosed classrooms, and the third floor is a semi-enclosed workshop area. This multi-functional design enabled the school to operate in different educational and communal roles. It responds to this community's need for accessible educational buildings. It was built from local materials such as wood and bamboo, a choice which helped to keep the costs low and provide a sense of cultural suitability.[59] It was designed to be low-cost and replicable for other such communities in the same contexts. This use of local materials also had a beneficial effect on the local economy.[60]

As global warming increases flooding and sea level rise, the demand for floating buildings is expanding at a fast pace, especially for impoverished communities such as Makoko that are not able to pay for traditional flood control measures.

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[57] Ibid
[58] Ibid
[59] Irina Vinnitskaya, "Makoko Floating School / NLÉ," ArchDaily, March 14, 2013, https://www.archdaily.com/344047/makoko-floating-school-nle-architects.

[60] Ibid

The Makoko Floating School provided an alternative, adaptive, and vernacular solution that is sensitive to the environmental and climatic context locally.

In relation to this thesis, Makoko Floating School provides perspective on how floating infrastructure can be utilized to benefit not just marine communities but also human societies at large, especially where water-related problems affect such areas. The project provides a model for the development of critical services in exposed, aquatic ecosystems. It demonstrates that sustainable design can solve environmental and societal problems.

Case Study 4: The Sydney Opera House.

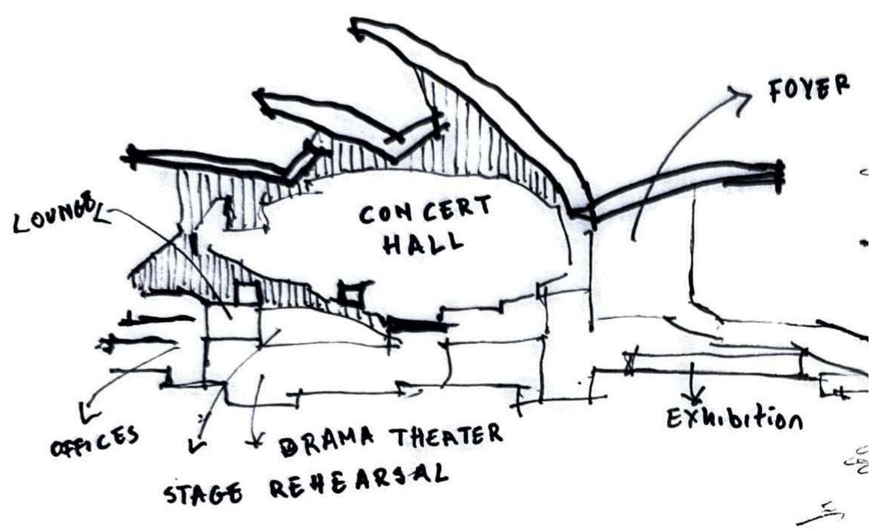

Illustration 9: Cross Section of the Sydney Opera House with programs.

The Sydney Opera House, which was created by Danish architect Jørn Utzon, is quite possibly the most recognizable architectural icon of the 20th century. Located on the Sydney Harbor's edge, the design of the building is a creative solution to its context. Its most identifiable element, the sail-like shells, echoes the nautical setting of the environment. Utzon's design, inspired by nature and the harbor context, produced a building that not only was aesthetically pleasing but also was rich in cultural significance to the harbor's identity. The Opera House became the icon of Sydney and was inscribed on the UNESCO World Heritage site.[61]

Finished in 1973, this building is quite a revolutionary engineering feat. Its design necessitated the creation of a new "ribbed roof system" that provided the building with its signature look while enabling it to retain structural stability. As a performing arts center, it draws in millions of people each year and hosts more than 1,500 performances each year.[62] The building has diverse programs—from opera and theater to contemporary music and visual arts.

Sydney Opera House teaches valuable lessons in the use of context-sensitive design. It adapts well to the natural and cultural urban environment

[61] "Sydney Opera House," UNESCO World Heritage Centre, accessed October 31, 2024, https://whc.unesco.org/en/list/166.
[62] "Our Story," Sydney Opera House, accessed October 31, 2024, https://www.sydneyoperahouse.com/our-story.html.

of the Sydney Harbor. The Opera House shows how waterfront design can serve as an interface between individuals and their surroundings. As architects, it is within the profession to develop spaces that are memorable, engaging, and meaningful. This case study is consistent with the thesis's objective of re-linking public space with the marine environment.

Conclusion

The study of these five precedents presents various solutions to the integration of buildings into aquatic spaces; each responds uniquely to varied ecological, social, and cultural conditions.

The Oyster-tecture and Harbor Wetland demonstrate how sustainable design and ecological restoration can be used to improve urban waterfronts.

The Floating School and Floating Kayak Club at Makoko demonstrate resilient, flexible architecture in the face of fluctuating water levels and changing community demands. The Sydney Opera House demonstrates the potential for architecture to become a cultural icon that enhances, rather than distracts from, its waterfront setting and encourages public engagement.

Combined, these precedents inform how architecture can assist in resolving environmental issues, activate aquatic ecosystems, and encourage public interaction. These results inform the objectives of the thesis, which are to present sustainable design concepts that assist in the ecological restoration of the Chesapeake Bay.

Finally, this case study contributes to the thesis of mitigating ghost fishing effects through the application of robust and adaptive architectural interventions by demonstrating how design can establish habitats that facilitate coexistence with natural environments.

Chapter 5: Zones and Program

As the Bay has current and potential future risks related to ghost fishing, it is important to learn about the dynamic nature of the coastal zones and how they can affect the necessary zones and programs choice for this thesis. The trend of sea level rise which will then be discussed in chapter 06 gives an idea of how the programs need to move forward. Floating farming and eco-friendly aquaculture are some of the possibilities that emerge when considering this phenomenon. Therefore, the planned program is built on three central zones, Education, Exhibition, and Habitat Restoration. These three zones as a collective represent an integrative strategy for addressing ghost fishing through the two recurring themes of this thesis: education and public participation.

Since the three program zones are based upon and investigate research on floating structures and habitat restoration, they were also chosen with a particular interest in how the rising sea level could affect the coastal zones. They illustrate how such environmental changes could be an opportunity for introducing new marine species restoration through the deployment of adaptive architectural strategies that involve incorporating environmental stewardship and public engagement. A specific precedent will be reverse-engineered to inform the program's resilience strategy in aquatic ecosystems and adaptation to changing environmental conditions. This is the Makoko Floating School prototype in Lagos, Nigeria.

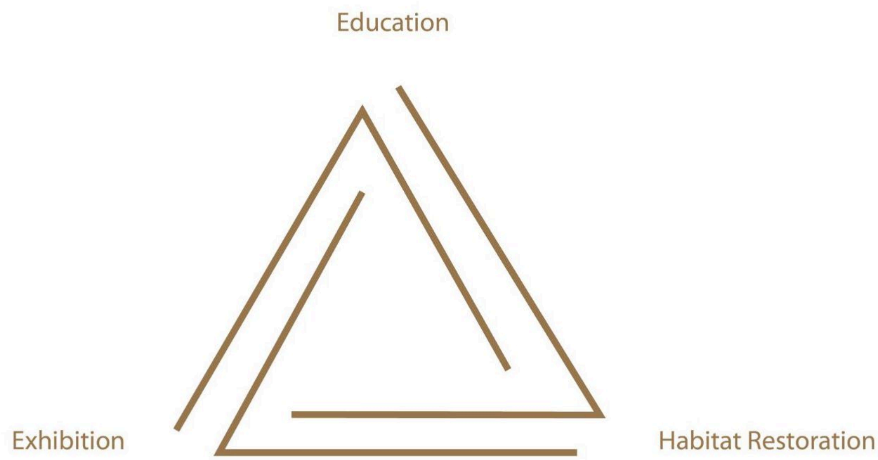

Illustration 10: Program zones.

Education Zone

The Education Zone will be the initial zone of this project. It is a foundation for community education and outreach. It may be done through traditional mediums or interactive digital presentations. As traditional mediums, these centers try to involve the visitors in pertinent subject material through classrooms, lecture areas, or workshops. But the state of discarded fishing gear and habitat devastation in its trail calls for a special kind of response that will engage tourists and enthusiasts alike in the subject of this problem, its environmental impact, and the special role of architecture in aiding restoration efforts.

The space will be built with the aim of developing a sense of belonging among the visitors and the ecosystem of Chesapeake Bay with the hope of developing in the public a sense of environmental stewardship as well as the need to act upon it. A wide view and exposure to water and the outside world will be the two prime necessities for the space. In addition, selection of the location will also be an important element in meeting this goal. Where there is already an educational institution that is found, this program area will be complemented by it because such a facility might have an enormous pool of knowledge that could not otherwise be accommodated in this space.

The Education Zone layout is guided by studies of the psychological rewards of nature-immersed settings. It is to be laid out as a space for interaction and communication with other people and with experts involved in reducing the impacts of human activities on marine ecosystems. Programming can incorporate large immersive meeting areas, interactive exhibits showing the coastal ecosystems' ecological processes, and guide narration and questions and answers.

To offer visitors an enriching experience, the Education Zone will incorporate ongoing research on adaptive educational methods of environmental conservation. Through interactive experiences that range from more complex endeavors such as participation in model-building workshops for floating structures to less complex activities such as feeding marine life or harvesting the farm, these elements will work to provide a learning environment that conveys the urgency of ecological restoration and the potential of architectural intervention.

Exhibition Zone

Directly adjacent to the education zone will be the Exhibition Zone. An exhibition area will be provided that will act as an interactive forum to support public awareness through a series of multimedia installations expressing the issue of ghost fishing, the importance of sustainable design, and the architectural solutions inherent in the program. While the education area will strive to create an experience of learning as a group, the exhibit area will be a space of Independent learning and contemplation. The guests will not be guided and may select certain areas within this theme to focus on. Its purpose is to translate complex environmental issues, such as ghost fishing and sea-level rise and how it affects marine life, to readable and engaging information for the masses.

This Exhibition Area will present ghost fishing within the larger context of marine conservation through digital installations, sea-level rise simulation, infographic displays, and artifact displays of derelict fisheries gear removed from the Bay. Augmented reality stations are also a potential feature. These will enable individuals to visualize the projected effects of sea-level rise and the possible restoration work enabled by floating structures. This interactive nature of the information makes it tangible and memorable. As science has well proven, individuals are much more likely to remember information if it is interactive. The

Exhibition Zone's design can be extremely flexible. Like museums, the exhibitions will be temporary in nature and provide the ability to make changes to the installations as new research or ecological information becomes available.

Habitat Restoration Zone

Finally, the Habitat Restoration Zone will be a special zone that will provide space for ecological recovery, emphasizing submerged and floating structures that aim to assist in restoring biodiversity and habitat for aquatic organisms. The habitat restoration zone will be area for completely mature species to grow and establish a stronger ecosystem.

The restoration area of habitat will act as a reservoir or stock provision to control the number of marine species and maintain a balance of the ecosystem. During the time when there can be less breeding, the species from this zone reserve can be released into the water to facilitate their population increase.

This zone will start with artificial reefs and anchored vegetative beds that will attract a variety of marine life and promote the growth of native flora and fauna. Over time, the artificial reefs will be replaced by natural reefs. It is an assisted restoration effort which will make way for the future natural restoration.

The knowledge of how all the species will be affected by sea level rise will make it possible for the architectural design of such floating structures to be adaptable even if there is a shift in tides and floods. Platforms, decks, and walkways will be created to maximize tourist access and reduce the effect on the aquatic environment. There will be plenty of public viewing area provision.

1. *Program Documentation*

The organization of this program draws heavily from the annotated bibliographies, with studies on floating architecture, resilient aquaponic systems, and habitat resilience in aquatic environments guiding the vision for each zone. For example, studies on floating architecture are directly applied to the Habitat Restoration zone. For the Education and Exhibition zones, environmental communication scholarship was the guiding approach to visitor experience.

Tabulation is included with the program, with each zone's goals, design approaches, materials, and specific activities, providing clarity on how the program works as a whole and in accordance with research results. Graphic documentation additionally reveals spatial relationships, ecological processes, and visitor points of interaction, determining how architecture responds to both public engagement and environmental restoration.

2. *Reverse Engineering: The Makoko Floating School*

Reverse Engineering		
Makoko Project		
Program Zones		
Program	SQF	Count
Community Engagement		
Workshop	520	1
Education		
Classroom	540	1
Cultural Space		
Play area	1,024	1
Total	**2,084**	**1**
Circulation		
Stair	40	1
Total	**40**	**1**
Non-Usable Space		
Framing	246	
Total	**246**	**1**
Overall Total	**2370**	

Table 2: Program zones for the Makoko project.

The precedent of preference was the Makoko Floating School, a floating community structure in Lagos, Nigeria, because it is an innovative solution to adaptive architecture in water. Although its program spaces vary from the program spaces targeted here, the precedent is applicable to designing a floating building. This floating building, as conceived by architect Kunlé Adeyemi, represents the resilience, low-impact planning, and adaptability that this program envisions for the Chesapeake Bay context. The reverse engineering of Makoko School gives a profound insight into how analogous architectural ideas can be used to adapt to sea level rise as well as habitat restoration. The most important lessons from this project are as follows:

- **Floating Foundation for Resilience**: Makoko School's floating foundation is a testament to resilience in the case of rising water levels, a critical factor in the tidal Chesapeake Bay environment. The Chesapeake Bay Program estimates a sea level rise between 1.3 and 5.2 feet within the next 100 years. Reverse engineering of the feature relies on material selection, structural approaches, and provision for fluctuating levels of water, especially in the Aquaculture and Habitat Restoration sections.

- **Community Engagement and Educational Utility**: Makoko has multifunctional spaces, serving both educational and community purposes. It demonstrates how architecture can support both social and environmental agendas. This is carried through to the Education and Exhibition areas, where community spaces are included to engage the public actively in nature conservation and ecological education.
- **Environmentally Sensitive and Low-Impact Design**: Local, sustainable material use by Makoko dictates the direction of this program for minimal environmental disturbance. Every space utilizes materials selected for longevity in aquatic environments and ecological harmony, such that the architecture permits the restoration of the Bay

without further pressure. The Makoko Floating School in Lagos, Nigeria, was selected as a preferred precedent due to its intelligent solution for dynamic water architecture. Though its program zones are different from the proposed program zones here, the precedent still instructs us on how to go about designing a floating building.

The precedent of Makoko Floating School was selected over others since it represents a pragmatic approach to the design of low-impact, resilient, floating structures that align with this thesis's objective of designing a school building for the community. The lessons observed herein are applied in an architectural program that is not only resilient and adaptive to environmental change but also one that is robust in community engagement and environmental stewardship.

Conclusion

This thesis of architecture to mitigate ghost fishing in the Chesapeake Bay integrates research on effective methods of education, aquaculture, and habitat restoration. Looking at strong solutions such as floating structures and resilient architecture that can survive regardless of climate change provides the thesis with a better foundation. The four zones of the program were selected—Education, Aquaculture, Exhibition, and Habitat

Restoration. Each with its own theme, the project offers a more cohesive experience for visitors to observe, learn about, and participate in the restoration effort.

Chapter 6: Site Selection and Analysis

Site Selection Abstract

The process of selecting the site was informed by a thorough analysis of the Chesapeake Bay ecosystem, in addition to professional guidance from the thesis chair. A set of criteria was first identified and divided into three categories: ecological factors, accessibility factors, and design/program-specific factors. The initial list included 17 criteria, which were then narrowed down to six main considerations. The six criteria that are delineated correspond with the project's objectives, which are to facilitate habitat restoration initiatives while actively involving the community in educational endeavors. These are ranked in order: proximity to affected marine ecosystems, ecological considerations, ability to promote habitat restoration, suitability for the advancement of sustainable aquaculture, resilience to environmental forces, and public accessibility.

Using these identified criteria as a starting point, Geographic Information System (GIS) data provided by the Chesapeake Bay Foundation (CBF) was examined to identify potential sites. The project is not expected to result in building conventional buildings or structures but instead, focus on wetlands restoration from ghost fishing activities. Therefore, the focus of the analysis profiled sites in or near existing educational endeavors or research facilities as these organizations support the intent of this proposal. The initial search yielded 10 potential sites with CBF educational or research programs on location.

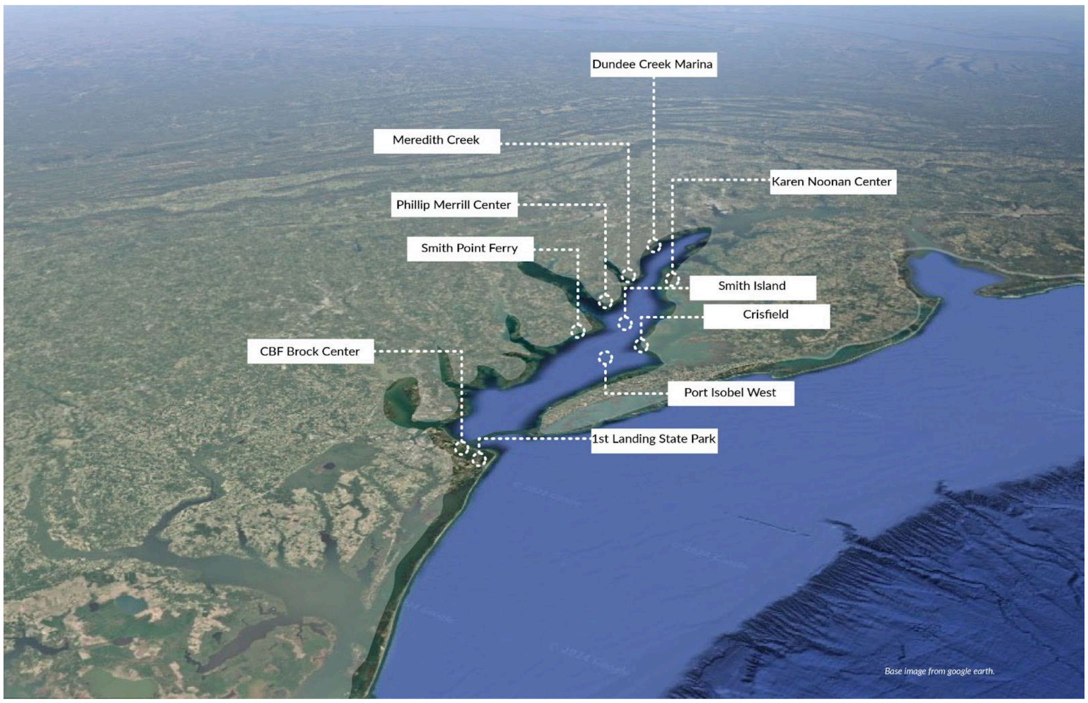

Illustration 11: Potential sites with CBF buildings on site along the Chesapeake Bay.

Thereafter, more stringent criteria were added to further narrow the selection. A more detailed analysis looked at coastal areas of the portion of the Chesapeake Bay that has potential for aquaculture development and submerged Aquatic Vegetation (SAV). The 3 maps were then overlaid to inform site selection decisions.

After the filter, three sites met the aforementioned requirements: the Phillip Merrill Center in Annapolis, Maryland, the Karen Noonan Center in Crocheron, Maryland, and the Smith Point Marina in Reedville, Virginia. Each had receding SAV, host wetlands suitable for aquaculture, and had existing education or research facilities on-site. They were also accessible to the public and sited along the coast. Further research is necessary to determine other ecological factors such as pollution levels, behavioral patterns, death rates, and the migrational patterns of indigenous species. However, for the purposes of this research, the above three factors were deemed sufficient to make an informed decision when selecting a site.

Site Selection Matrix

A matrix was created to prioritize every site in relation to six criteria. Each of the six criteria was rated between one and five, and the bigger the number, the nearer to the project goals. The six criteria and their definitions that were utilized in this research are listed below:

- **Proximity to Impacted Marine Ecosystems:** The location offers direct access to or closeness to the areas that must be restored, including seagrass beds, wetlands, and oyster and blue crab habitat.
- **Ecological factors:** include pollution levels, behavior patterns of organisms, their migratory patterns, and reproductive behavior, as all of these have a direct impact on restoration.

- **Potential to Support Habitat Restoration:** The potential attribute was aimed at a more fundamental evaluation of water and soil status through image analysis. Particular emphasis was given to the degree of habitat degradation in order to establish the likelihood of success of an effective intervention.
- **Feasibility for Sustainable Aquaculture Development:** How well the sites can be suited to host aquaculture activities such as fish farming or oyster farming was examined. All sites were found to be suitable with the filter used before.
- **Resilience to Environmental Factors:** This is a site long-term viability consideration. Among the considerations are risks from climate change and other related issues like sea-level rise concerns and flooding.
- **Accessibility to the Public:** public access to facilities and roads was crucial in encouraging community participation and enabling site visits.

According to this matrix, all of the sites were evaluated according to these pre-determined criteria. Philip Merrill Environmental Center and Karen Noonan Memorial Environmental Education Center emerged as the top sites, each of which scored a total of 27 points. Although both locations shared the same rating, Philip Merrill site was the preferred site because of its adaptability to future sea-level rise. Smith Point Marina, on the other hand, scored low with 22 points, something that will be addressed in the points given in the next section.

Such comparisons highlight the respective strengths and weaknesses of each site and thus provide an objective basis for the final choice.

Site Selection Matrix

Criteria	Phillip Merrill Center	Karen Noonan Center	Smith Point Ferry
Proximity to Impacted Marine Ecosystems/location	4	5	3
Ecological factors	5	5	4
Potential for support for Habitat Restoration Projects	5	5	2
Feasibility for Sustainable Aquaculture Development	3	5	3
Resilience to Environmental Factors	5	4	5
Accessibility to Public	5	3	5
Total	27	27	22

The following ranking was determined on a scale of 1 to 5, with 1 being the lowest and 5 the highest.

Table 3: Site Selection Matrix. The following ranking was determined on a scale of 1 to 5, with 1 being the lowest and 5 the highest.

Analysis of Non-Selected Sites

The Karen Noonan Environmental Education Center sits on 20 acres of marsh in Dorchester County, with close proximity to a variety of aquatic habitats like the Blackwater National Wildlife Refuge.[63] The land is ecologically valuable in terms of marsh and Submerged Aquatic Vegetation (SAV) restoration and thus a suitable candidate site for species like oysters and blue crabs. Yet, there are

[63] "Karen Noonan Memorial Environmental Education Center," Chesapeake Bay Foundation, accessed November 14, 2024, https://www.cbf.org/about-cbf/locations/maryland/facilities/karen-noonan-memorial-environmental-education-center.html.

several strengths that run down the middle: long-term feasibility is greatly jeopardized by the anticipated increasing sea levels. Estimates suggest that a large portion of the site would be underwater within 50 years, which would subsequently greatly restrict accessibility and usability for both restoration and education programs.

Additionally, the isolation of the site makes the regular community involvement and programming required to achieve these objectives challenging. The location was therefore finally not suited, although it met the ecological requirements of the project, due to these constraints.

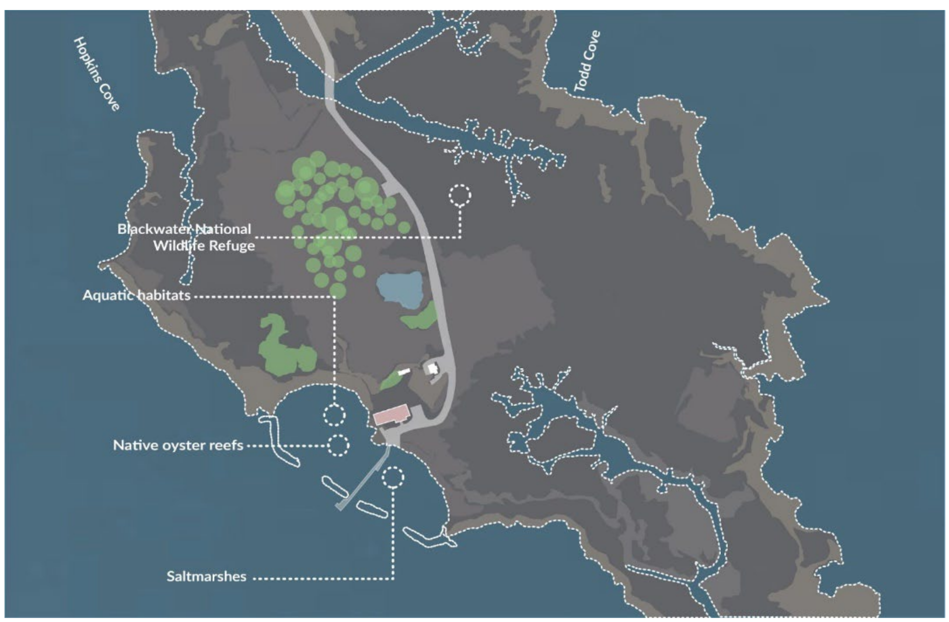

Illustration 12: The Karen Noonan Memorial Environmental Education Center: Site plan.

Illustration 13: : (Left) projected sea level rise in 50 years. (Right) projected sea level rise in 100 years. Graphics made by the student. Data from NOAA.

The Smith Point Marina in Reedville, Virginia, presented a special set of complications. The marina is traveled, drawing tourists and boaters and thus creating high degrees of noise pollution, water pollution, and physical disturbance to the local environment. These are not circumstances that are supportive of effective habitat restoration or the development of aquaculture initiatives.

Although the marina already enjoys great public access and has infrastructure that lends itself well to educational utilization, commercialization of the marina is the antithesis of what the ultimate goal of the project is, which is ecological restoration. The drawbacks, therefore, outbalanced the benefits. This limitation ranked lower in the overall evaluation.

Illustration 14: The Smith Point Marina: Site plan.

Illustration 15: The Smith Point Marina: projected sea level rise in 50 and 100 years.

As an environmental headquarters for the Chesapeake Bay Foundation, the building is one of the landmark examples of environmental stewardship and sustainable design. Situated directly adjacent to the Chesapeake Bay, it has immediate access to affected ecosystems. It is thus a highly appropriate site for aquaculture and habitat restoration activities.

From a restoration ecology perspective, the site offers numerous possibilities. Its surrounding waters are suitable for SAV planting, oyster culture, and wetland restoration. The fact that it is also near degraded habitat types, like seagrass beds and wetlands, makes it even more qualified for intervention. More importantly, the center was designed with climate resilience in mind. Its pilings ensure resilience to flooding and high tides.

Preferred Site Selection and Analysis

Apart from its environmental features, the Philip Merrill Environmental Center has good infrastructure that supports its functional effectiveness. It contains conference rooms and open office spaces.[64] It is a great facility for hosting workshops, lectures, and interactive exhibits that engage the general public in marine conservation efforts. Its proximity to population centers in Maryland also contributes to its usefulness as a focal point for restoration and education activity.

[64] "Philip Merrill Environmental Center." Chesapeake Bay Foundation. Accessed November 14, 2024. https://www.cbf.org/about-cbf/locations/maryland/facilities/philip-merrill-environmental-center/index.html.

accordance with this project. Features like passive ventilation and heating using natural means and recycled materials reduce its footprint while also acting as teaching aids.[2] Generally, the building itself received numerous green certifications and several awards, most prominently the LEED Platinum certification.

Because of sustainable features, the four programmatic areas covered in this thesis: Education, Exhibition, Aquaculture, and Habitat Restoration—can be integrated into the current shape of the center. Two of these four programmatic areas are housed by the center: education and exhibition. The exhibit and educational components of the building infrastructure are utilized to enlist community participation, and the aquaculture and habitat restoration components will use the surrounding ecological site and wetland for practical conservation activity. This level of integration between site, program, and strategy generates a consistent and viable proposal.

Illustration 16: The Philip Merrill Environmental Center: Site Plan.

Illustration 17: The Philip Merrill Environmental Center: projected sea level rise in 50 and 100 years.

Cocnlusion

The choice of the Philip Merrill Environmental Center as the preferred location exemplifies a strategy that integrates ecological, programmatic, and architectural factors. Its ability to withstand environmental fluctuations, including rising sea levels, renders it a suitable selection. The site's closeness to impaired ecosystems and its appropriateness for restoration efforts, such as submerged aquatic vegetation cultivation and oyster aquaculture, directly enhance the ecological aspect of this initiative. Concurrently, the center's strong infrastructure promotes community involvement via educational and public programming activities.

This proposal recaps the issues that are associated with ghost fishing and derelict fishing gear and proposes that a combination of ecological restoration and public education is a more viable pathway to meaningful solutions. The Philip Merrill Environmental Center demonstrates how site and design can contribute to both ecological restoration and public outreach. The significance of such an approach is not only to protect biodiversity but also to advance the harmony between human activities and marine ecosystems.

The project would have a lasting, profound effect on the Chesapeake Bay, while also creating broader environmental activities. The site selection can illustrate how architecture can be utilized as a powerful tool for ecological and societal change. This is a replicable model for similar problems in many other regions.

Chapter 7: Conceptual Testing of the Site

Introduction

This chapter traces the turning point when research began to translate into architectural form. Earlier chapters examined the consequences of ghost fishing and the potential for architecture to serve as a restorative agent in Chesapeake Bay. However, as conceptual testing began, it became clear that addressing ghost fishing directly through design was far less feasible than initially imagined. The nature of ghost gear, often invisible, scattered, and mobile, posed practical limits for a design-driven intervention.

As investigations widened, the focus began to shift. Ghost fishing was still the origin of the thesis, but it no longer stood alone as the central design problem. Instead, the physical reality of the site, the complexity of the region's vegetation, and its proximity to the Chesapeake Bay, a new opportunity was discovered—one that brought ghost forests, sea level rise, and oysters into closer dialogue. These three elements emerged not just as context, but as catalysts for the architecture.

What followed was a redefinition of scope. Rather than chasing ghost gear across unpredictable water of the Chesapeake Bay, the thesis gravitated toward the conditions that ghost fishing leaves in its wake: coastal retreat, ecological loss, and opportunities for restoration. The architecture became less about intervening in ghost gear directly and more about responding to the broader landscape it leaves behind. This shift informed every aspect of the conceptual design process, from massing and circulation to tectonics and ecological integration.

Early Parti and Massing Studies

The first set of design explorations began with simple spatial programming: edges, linear paths, fragmented forms, and building outlines. Each parti was an attempt to map a journey—across ground that was covering the entire site. A key challenge was how to engage both land and water without favoring one over the other.

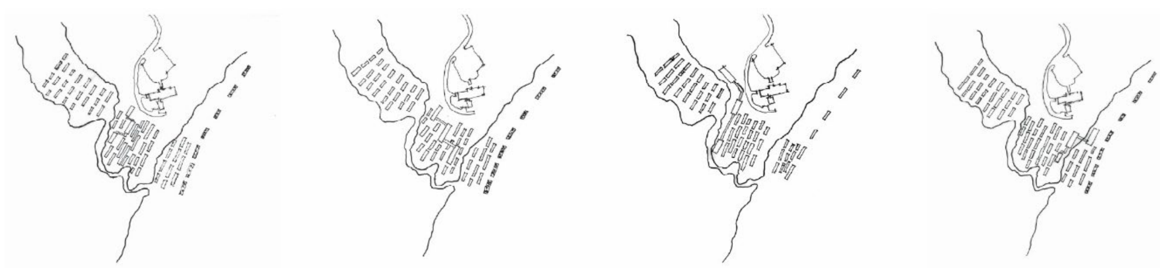

Illustration 18: Different Building testing on the site

On the first early scheme, the buildings are oriented on the west side of the site with an alternating pattern. On the second scheme, the buildings are spread out in a stepping pattern. The third scheme has the building spread north-south on the west side of the forested area to the left of the Philip Merrill Building. The fourth scheme is a hybrid mix of the first and third, but this time, situated on the East side towards the Chesapeake Bay. All four schemes offered clear zoning: exhibition spaces on land and oyster habitats in water.

As the design progressed, certain themes became hierarchically more pronounced than others. The idea of an oyster promenade became more dominant. As such, a boardwalk was needed to support this concept. Ultimately, the selected scheme became a hybrid: a branching system of walkways and platforms that begins within the existing parking lot, traces the tidal zone of the Black Walnut Creek, and ends above reef restoration areas on the Chesapeake Bay. The architecture follows an ecological sequence rather than a purely functional one. It does not cut across the land. It travels with it. Thus, the final scheme built upon the second scheme and expanded the distance between the buildings to involve both the Black Walnut Creek and the Chesapeake Bay.

This progression was shaped by the realization that the ghost forest—those skeletal remains of drowned pine—offered something the open water could not: a legible, haunting, and powerful narrative of climate change. It marked a place of loss, but also one of potential. Starting there became the foundation for everything else.

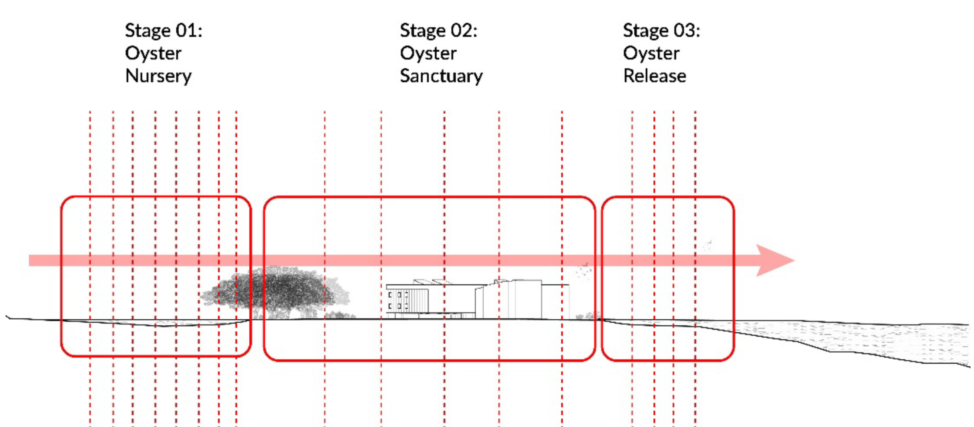

Illustration 19: Early conceptual design of the oyster promenade.

Conceptual Drivers and Spatial Translation

The conceptual framework for the thesis crystallized into three core ideas, each directly influencing spatial and material choices:

1. **Reveal What's Normally Hidden**

   Ghost gear, like sea level rise, often escapes perception. So the architecture responds by making the unseen visible. Sections dip below water, paths expose submerged oyster systems, and exhibits draw visitors into the stories of damaged coastlines and dying forests.

2. **Participate in Ecological Cycles**

   The architecture is not a backdrop—it is a participant. Oyster reef balls are embedded in the promenade. Fuzzy ropes hang from shaded canopies. Oyster rack and bags hang on water to support juvenile oysters.

3. **Build with Change, Not Against It**

   Instead of resisting sea level rise, the architecture adapts to it. Portions of the structure such as ramps are designed to be overtaken by water over the coming decades. Some paths will become submerged. The project is less about permanence and more about endurance.

These principles shaped how the program was arranged. The educational zone was placed deeper into the anticipated ghost forest to frame the climax of the visitor journey. Labs and oyster nurseries also took athe center stage, both symbolically and practically. Service areas such as reefs floated just offshore—out of reach, but visible and real.

Tectonic Strategies and Ecological Infrastructure

From the outset, the project avoided the language of monumental architecture. Instead, it took cues from aquaculture, temporary structures, and low-tech environmental systems. The result is a tectonic palette that prioritizes ecological participation over permanence.

Fuzzy Rope Installations: These horizontal ropes, suspended from canopy frames, support oyster spat in early stages of growth. They also act as natural filters and help clean the water. The ropes are simple, low-cost, and alive. Over time, they accumulate marine organisms and begin to visually reflect the health of the bay. In architecture, they also become atmospheric elements. They cast shadows, move with the wind, and become an art installation anticipating future sea level rise.

Rack-and-Bag Zones: Shallow areas of the Black Walnut Creek near the beginning of the promenade feature traditional rack-and-bag systems. Each rack holds mesh bags where oysters can grow while protected from predators. These are not isolated installations; they are part of the visitor path, positioned alongside boardwalks so that the cultivation process becomes part of the spatial experience.

Reef Ball Foundations: Reef balls, perforated, dome-like concrete structures, are placed just offshore on the Bay to anchor in place for coast protection against tidal waves similar to breakwater. They also serve as habitat for marine life and attachment points for oyster reefs. At low tide, visitors can see their tops. At high tide, they vanish. Over time, these balls become living anchors, coated in oysters and marine vegetation.

Each of these elements works doubly—as infrastructure for ecological restoration and as structure for human interaction. The tectonics are quiet, but present. They support life without overwhelming it.

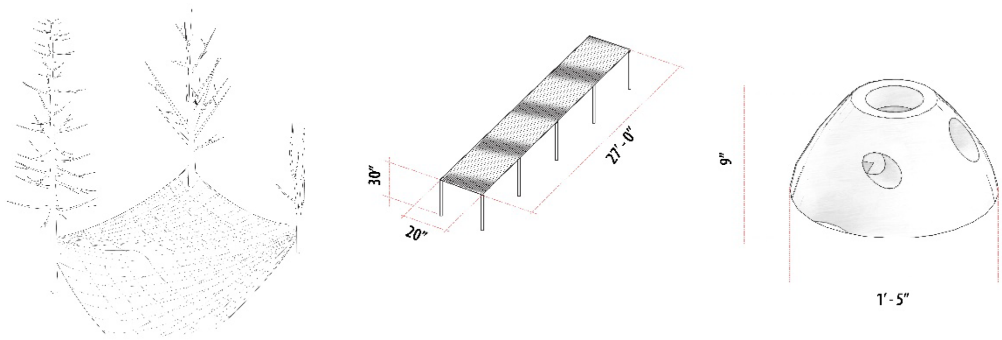

Illustration 20: From left to right: diagram illustrations of fuzzy rope, oyster rack and bag support, and reef balls.

<u>*Precedent Insights and Lesson Learned*</u>

Precedent studies earlier in the thesis offered a range of inspirations, from speculative to build. Each played a role in shaping the tone and technique of this project. As the design developed, some precedents became less relevant than others. One precedent was added due to its design significance and relevance tied to the sequence of promenade. The following is the final list of precedents retained.

- **Marine Education Center (Lake|Flato)**: This precedent emphasized a light footprint, fragmented program layout, and seamless integration with landscape. The takeaway here was the value of dispersal, of not trying to consolidate everything into one building, but rather allowing the program to unfold across space and ecological zones for a better promenade.

- **Oyster-Tecture (Kate Orff)**: While more speculative in nature, this project underscored the importance of designing with living systems. It reminded this thesis that marine infrastructure does not have to be hidden. It can be part of the experience, even celebrated.
- **Makoko Floating School (Kunlé Adeyemi)**: this project validated the idea that impermanent structures can still carry cultural and architectural weight. Although the thesis does not float its entire structure, parts of it draw on this ethos, light, responsive, and willing to let go of traditional form.

Rather than imitate, these precedents encourage a mindset of responsiveness, care, and respect for natural systems.

<u>Designing with the Site</u>

Located adjacent to the Philip Merrill Environmental Center, the site is already home to environmental advocacy and education. But its condition is fragile. Ghost forests are advancing inland, eelgrass beds are thinning, and storm surge is becoming more frequent. These observations, along with mapping data and NOAA projections, shaped every move in the design.

- **Topographic Slopes and Access**: The upland portion offers just enough elevation to stage the entry and interpretive forest path. From there, the land drops toward trees, marshes, and shallow bays, which are the perfect condition for oyster installations and soft infrastructure.

- **Hydrology and Salinity**: Salinity levels increase toward the open bay, thus guiding where certain oyster systems can be placed. This gradient directly informed the zoning of reef balls and rack systems.
- **50- and 100-Year Sea Level Projections**: Anticipated sea rise helped shape the elevation strategy. Certain areas of boardwalks are placed low on purpose, knowing they will become submerged within the lifespan of the structure. Others are slightly elevated, with margins to remain usable even as the tide creeps in.
- **Biological Constraints**: Areas of submerged aquatic vegetation were avoided. The walkway spans above these regions, respecting their role in juvenile blue crab and fish habitats. Minimal shading and no dredging were key constraints honored through design.

The site was never a blank slate. It was more like the first collaborator, offering data, history, and limits. The proposed architecture listens to those limits and adjusts accordingly.

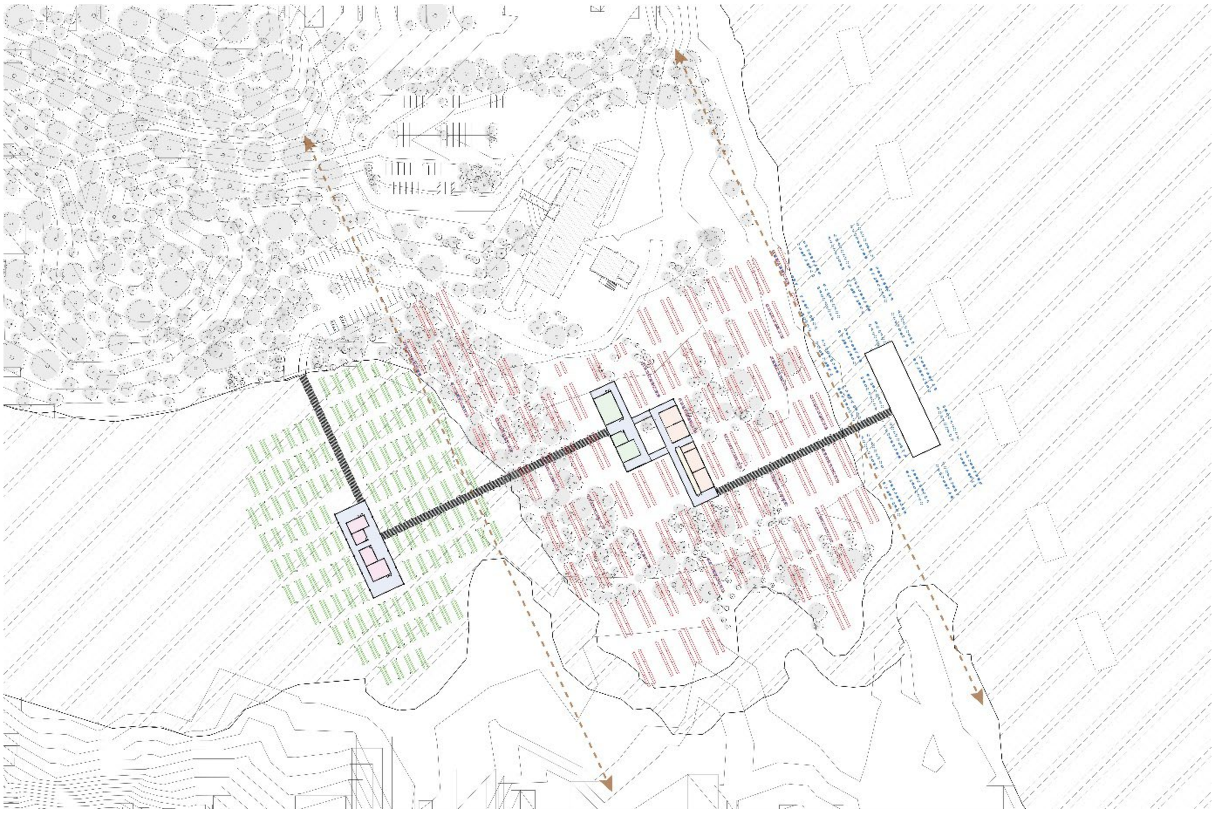

Illustration 21: Early site organization. Green: rack and bag system. Red: landscape pattern. Blue: concrete reef balls.

<u>Conclusion</u>

This conceptual phase was not about locking in a design. It was about learning what the site, the topography, and the systems required. And what became clear was this: an architectural response to ghost fishing had to be indirect but deliberate. It had to work with what is left: forests dying, oysters population receding, and water rising all still trying to offer something hopeful.

The result is a design that unfolds like a walk through time. It begins in a landscape of loss, transitions through zones of cultivation and learning, and ends in a quiet field of reef balls and fuzzy rope, a place where oysters, not people, take center stage.

This chapter marks the turning point from research to resolution. It clarifies the path ahead for the next chapter, where drawings, systems, and user experiences come into full view. The project is not an answer to ghost fishing. It is a response to the damage ghost fishing leaves behind, and a proposal for how architecture might stand beside that damage without pretending to fix it all.

Chapter 8: Conclusion – Thesis Design Solution

Introduction

This final chapter presents the comprehensive design solution developed through the research, conceptual testing, site investigations, and thematic studies conducted throughout this thesis. As earlier chapters revealed, this project began as a search for architectural responses to the growing environmental crisis caused by ghost fishing. However, as the research matured, it became evident that the more spatially and architecturally viable condition was not the ghost gear itself, but rather the ecological consequences it contributes to most notably, the emergence of ghost forests, the advance of sea level rise, and the collapse of oyster habitats within the Chesapeake Bay.

The practical work of this thesis centers around these three ecological conditions. Rather than offering a singular architectural object or a floating system, the proposal is a linear and site-specific intervention: a triptych of timber-framed structures distributed across the site to engage directly with environmental zones. Each of these zones is designed to respond to distinct conditions of salinity, depth, and ecological function. The result is a network of spaces that are at once infrastructural and experiential, instructional and restorative.

This chapter documents the spatial strategies, tectonic decisions, and projected outcomes of the design, while reflecting on the broader implications of architecture when placed within landscapes that are already in transition.

<u>Spatial Organization and Programmatic Logic</u>

The design is situated on the shoreline near the Philip Merrill Environmental Center in Annapolis, Maryland. This area, already home to the Chesapeake Bay Foundation, presents a unique opportunity to insert a project that complements existing educational and restoration efforts. However, the site also faces challenges: accelerated coastal erosion, increasingly frequent flooding, and the slow disappearance of maritime forest ecosystems.

The project is organized around a simple narrative sequence. It follows three interrelated zones. Each is anchored by a building and its surrounding environmental intervention. Together, they form a promenade that begins inland and descends gradually toward the Chesapeake Bay. The architectural logic of this sequence is grounded in the site's topography, ecological gradients, and projected sea level rise patterns.

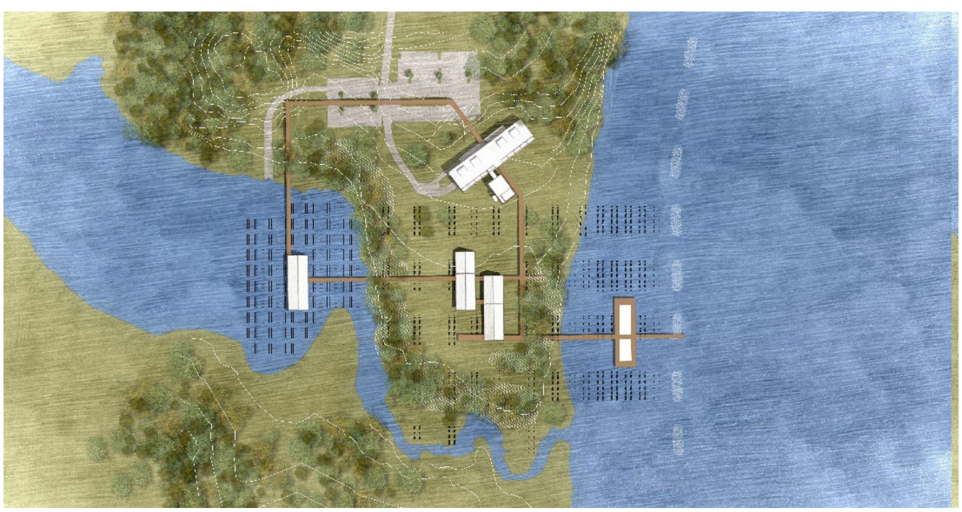

Illustration 22 Site Plan – Year 0.

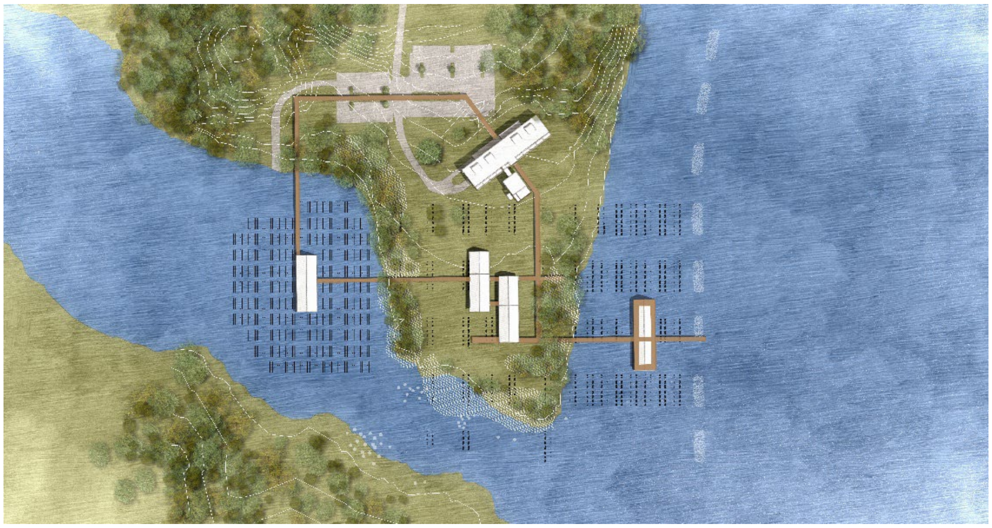

Illustration 23 Site Plan – Year 50.

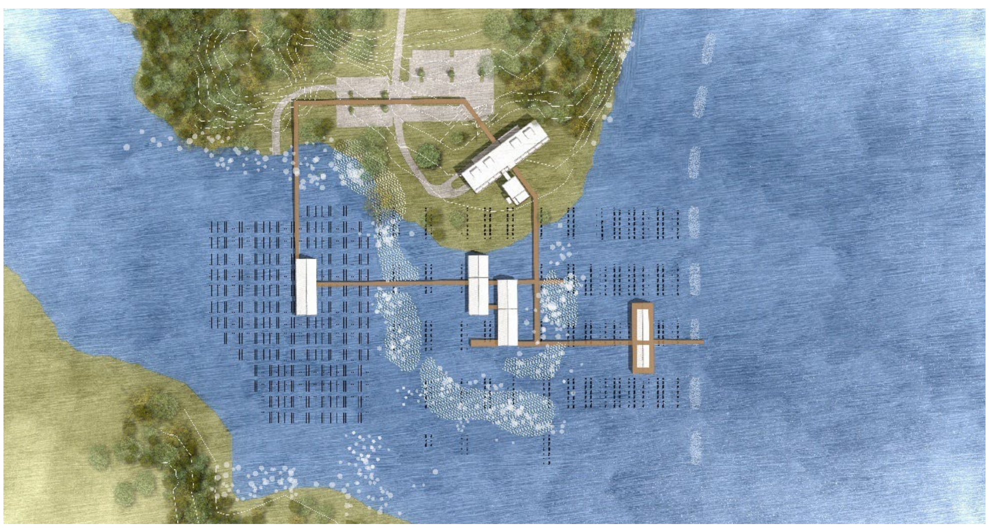

Illustration 24 : Site Plan – Year 100.

<u>*a. Oyster Nursery Building and Rack-and-Bag System at Black Walnut Creek*</u>

The first architectural zone is situated along Black Walnut Creek, at the northeastern edge of the site. This area is characterized by shallow water, low salinity, and gentle tidal exchange. These are optimal conditions for early-stage oyster growth using the rack-and-bag method. In this system, juvenile oysters are grown in mesh bags placed on steel racks positioned just above the creek bed. These installations protect the oysters from predators while allowing water flow to deliver nutrients.

Illustration 25: Oyster Nursery Building.

Adjacent to this aquaculture zone sits the Oyster Nursery Building, a compact, timber-framed structure raised on posts above the creek's floodplain. It contains sheltered workspace for hatchery volunteers, seasonal oyster farmers, and researchers managing the spat-on-shell process. The building is designed with open air sides to allow ventilation and ease of access to the nearby water. On-site activities include sorting, grading, and deploying oyster bags, as well as maintaining water quality logs.

A key experiential feature of this zone is that the rack-and-bag system is visible from the entry promenade. Visitors witness the nursery functions from an elevated walkway, making the otherwise opaque process of oyster cultivation legible and accessible. The intention is not only to restore oysters but to demystify the process of restoration itself.

b. Oyster Education and Research Building by the Fuzzy Rope Field

The middle zone is centered around the Oyster Education and Research Buildings, located on slightly lower ground near the forested portion of the site. Here, the architecture bridges between ecological instruction and research practice. The two buildings sit adjacent to a field of fuzzy ropes, vertical lines suspended into the water column that support oyster growth and attract other marine organisms. These ropes are an efficient form of oyster farming, particularly in mid-depth water where traditional reefs cannot easily form.

Both buildings are the largest of the three and houses multipurpose space for educational programming, exhibitions, and environmental monitoring. The structures are framed in timber and rests on vertical posts that account for minor flooding. Open-air classrooms and shaded platforms allow for flexible teaching formats and seasonal variation. Inside, wall panels include data visualizations, restoration maps, and historical documentation of ghost forest retreat and oyster decline.

Illustration 26: Oyster Fuzzy Rope Forest

Illustration 27: Oyster Education and Research Building

The buildings also provide a vantage point for observing the fuzzy rope installations, which extend into the water just east of the forest. Walkways from the building connect to small observation docks, allowing school groups and visitors to engage directly with the ecology of oyster growth. These fuzzy ropes double as ecological sensors, with their visible marine life accumulation offering clues to water health over time.

In contrast to the nursery, this zone is about interpretation. It offers visitors the opportunity to reflect on the science and stories behind oyster restoration and to understand the environmental stakes through a more immersive architectural setting.

c. Oyster Outlook Building and Reef Balls in the Chesapeake Bay

The final zone in the sequence reaches the open edge of the Chesapeake Bay. This area is exposed, saline-rich, and subject to higher wave activity. It is the most vulnerable section of the site but also the most critical for long-term restoration. Surrounding this area is a field of reef balls. These installations are designed to provide habitat for oysters while also reducing erosion and supporting biodiversity.

The Oyster Outlook Building is positioned at the terminus of the boardwalk. Slightly bigger than the education building, this structure serves as a contemplative platform and ecological outpost. Its design is intentionally minimal: an open-air shelter with simple seating, signage, and a direct view onto the reef ball field. The building sits on driven timber piles, allowing it to remain stable during high tides and mild storm events.

Illustration 28: Oyster Outlook Building

Visitors reach this point after passing through the previous zones. By this stage, they have moved from ghost forest to creek, from rack-and-bag to fuzzy rope, and now stand at the threshold between built environment and open water. The final zone is about observation. Here, the architectural intervention fades into the horizon, giving space for the bay itself to become the foreground.

Together, these three zones form a spatial narrative that follows the life cycle of the oyster and the progression of ecological engagement—from cultivation to learning to witnessing.

Tectonic Strategy and Constructional Intent

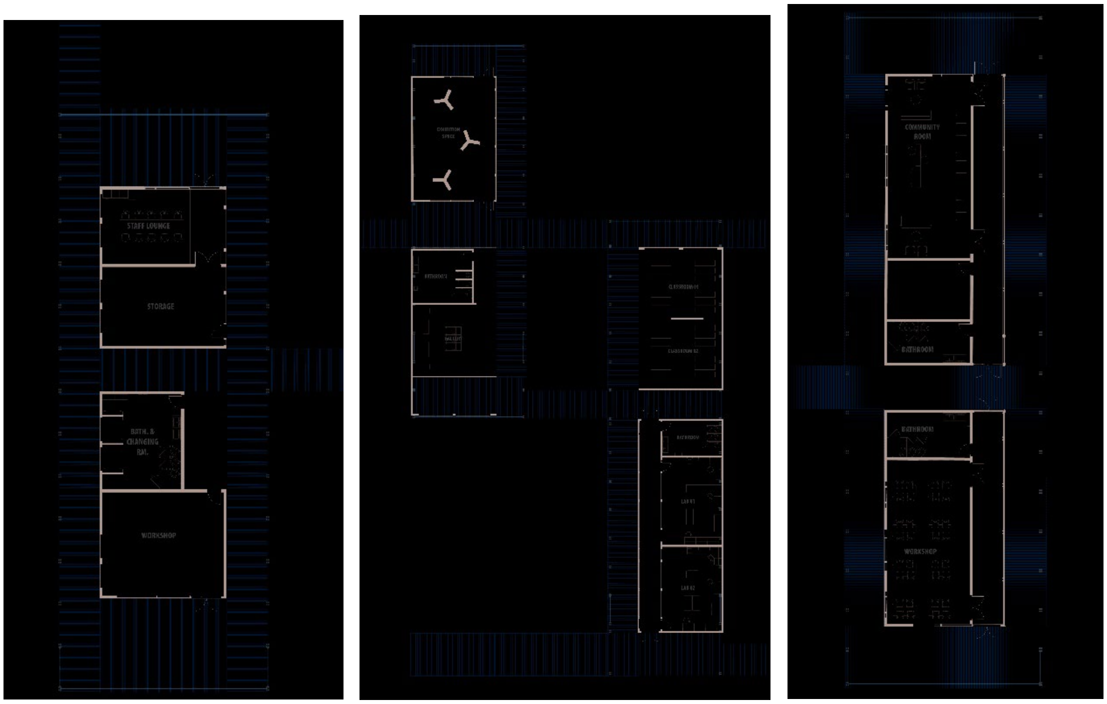

Illustration 29: Building Plans: From left to right: Oyster Nursery Building, Oyster Education and Research Buildings, and Outlook Building

All three buildings are designed with consistent tectonic principles. Their frames are constructed from regionally sourced timber and rest on vertical posts that allow water and sediment to flow beneath. The buildings are elevated above the floodplain, meeting regulatory requirements while allowing adaptation to sea level rise over time.

Cladding is minimal and breathable, relying on slated wood and operable panels to encourage airflow and reduce the need for mechanical systems. The roofs are simple pitched forms, optimized for rainwater collection in the nursery and research buildings. The outlook structure, being the most exposed, is more skeletal and utilitarian in form.

Materials are chosen not for iconicity but for integrity. Each structure is meant to weather, to show age, and to belong to the site. These are buildings that do not compete with the landscape but rather embed themselves within it. They do not float, nor do they dominate. Their restraint is part of their power.

The structural simplicity is intentional. It allows for community-based construction, maintenance, and potential replication at other coastal sites. It also aligns with the ecological ethos of the project: to do enough, but no more than what the site can support.

Ecological Performance and Metrics

The architectural elements of the thesis are supported by measurable ecological functions. The project includes detailed estimates of oyster population potential and water filtration capacity based on cultivation strategies deployed across the three zones.

At full capacity, the project supports the growth of approximately 312,000 oysters. This includes:

- Over 100,000 oysters grown through the rack-and-bag method at the nursery.
- Approximately 120,000 oysters suspended across the fuzzy rope field adjacent to the research building.
- An estimated 90,000 oysters are attached to and around the reef ball field in the bay.

Each mature oyster can filter up to 50 gallons of water per day. When aggregated, the oyster population has the potential to filter more than 15 million gallons of water daily under optimal conditions. This filtration improves clarity, reduces harmful algal blooms, and supports the reestablishment of submerged aquatic vegetation.

Beyond oysters, the reef ball field provides habitat for finfish, crustaceans, and other filter feeders. The combined effect is a layered and resilient ecological system that supports restoration beyond a single species.

Vegetated areas around the ghost forest are also enhanced with native grasses to support pollinator activity, absorb stormwater, and reduce erosion.

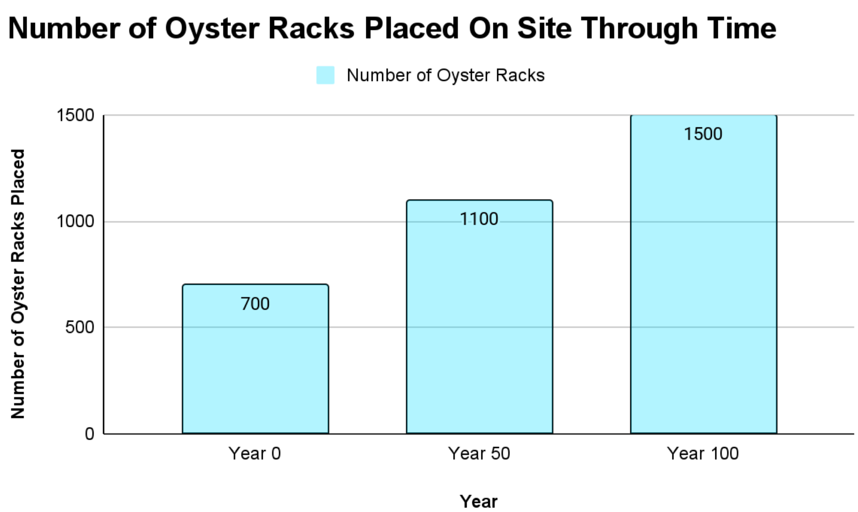

Illustration 30: Number of oyster racks placed on site.

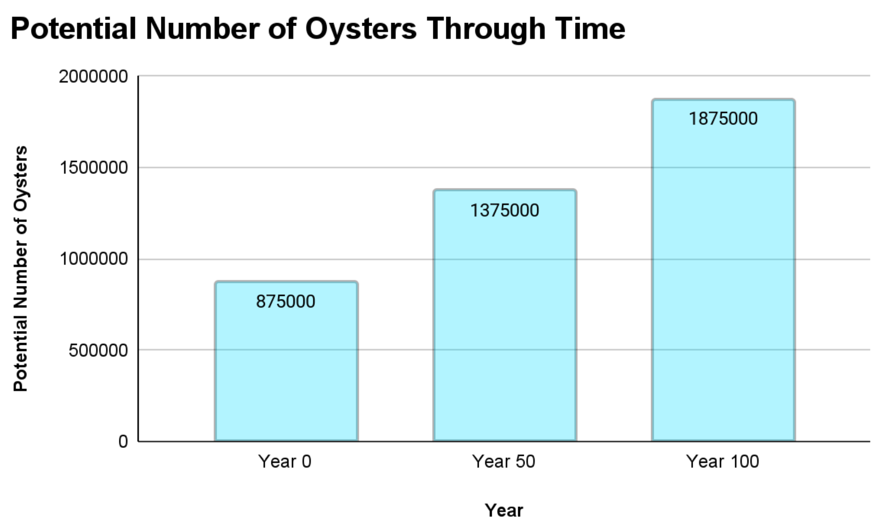

Illustration 31: : Potential number of oysters cultivated on site through racks and bags system.

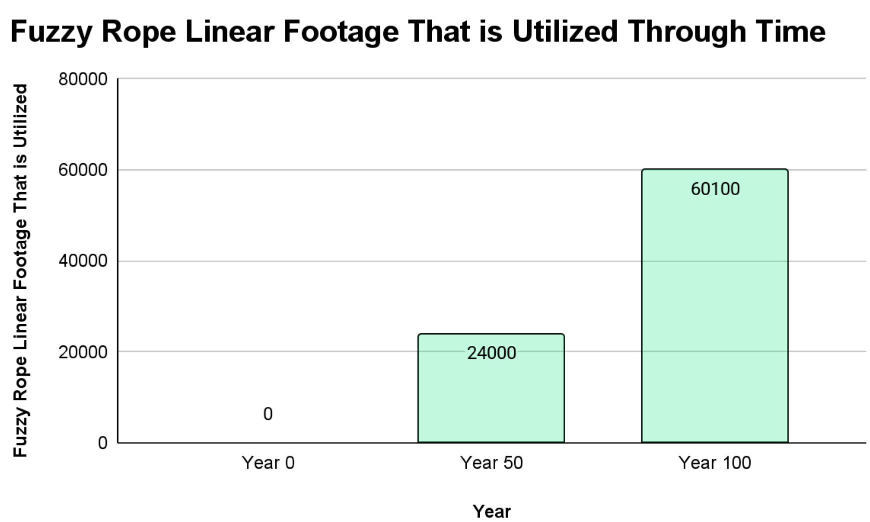

Illustration 32: Linear footage of fuzzy rope utilized on site.

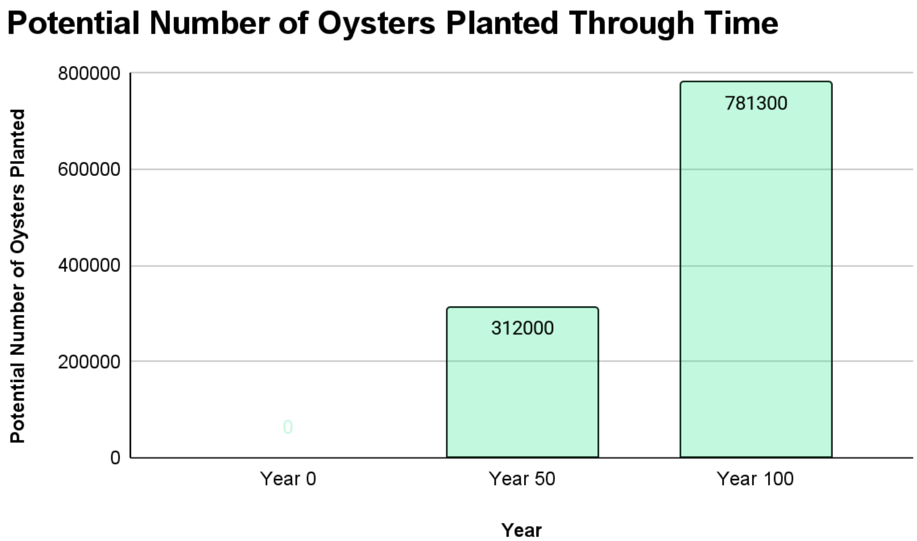

Illustration 33: Potential number of oysters planted on site through fuzzy rope.

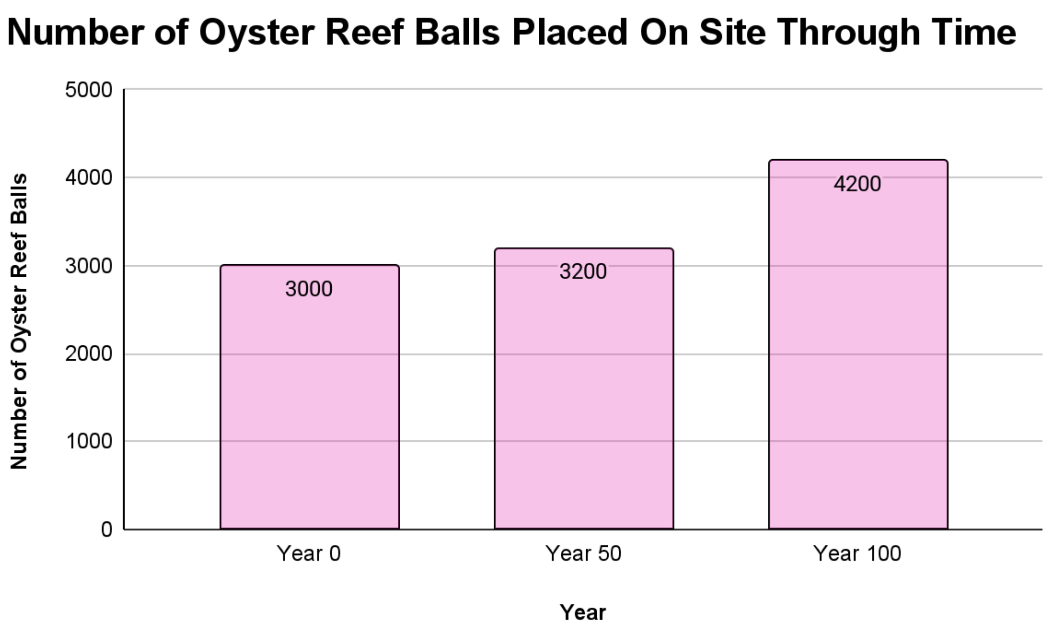

Illustration 34: Number of oyster reef balls placed on site.

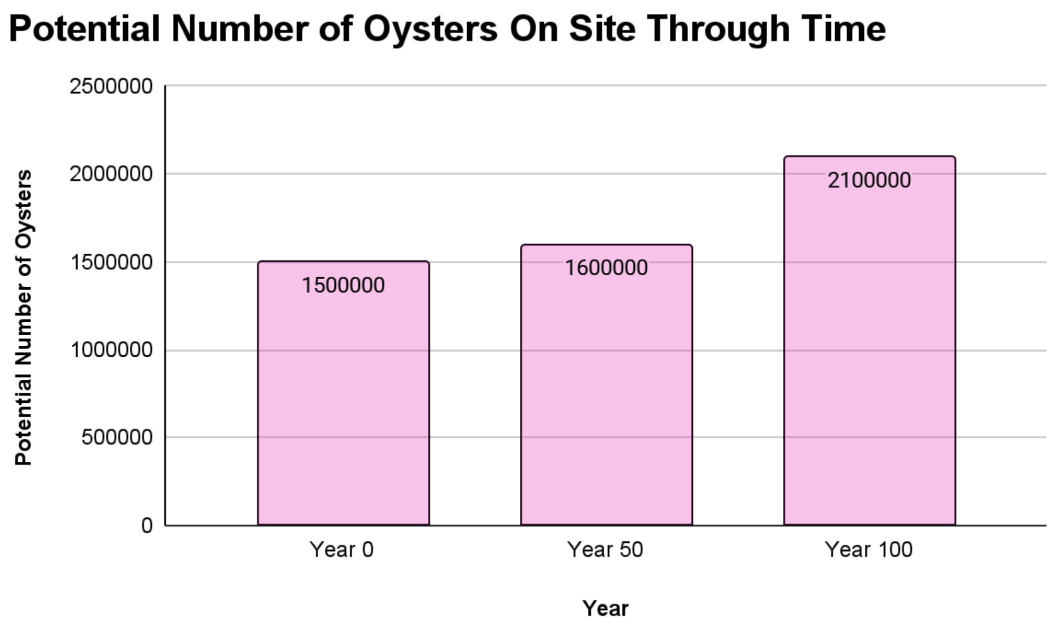

Illustration 35: Potential number of oysters planted on site through reef balls.

<u>*Community Engagement and Educational Impact*</u>

The design of the thesis is rooted not only in ecological function but also in community interaction. The three buildings are intentionally placed along a public pathway, open to school groups, residents, and visiting scientists. Each zone offers a different mode of engagement, from tactile work with oysters at the nursery, to guided tours and exhibitions at the research building, to reflective viewing at the outlook.

The buildings do not operate in isolation. Programming is designed in collaboration with organizations such as the Chesapeake Bay Foundation and local school districts. The aim is to integrate oyster restoration into science curricula, citizen science projects, and regional conservation efforts.

By allowing the architecture to serve both as infrastructure and curriculum, the project invites a broader demographic into the work of environmental repair. It challenges the notion that ecological restoration is the domain of experts alone. Instead, it becomes a civic project, with architecture acting as a bridge between knowledge and place.

Reflections on Design Evolution

The path from thesis question to design solution was not linear. Early versions of the project explored more direct interventions against ghost fishing, including speculative systems for retrieval and recycling. However, field research, precedent analysis, and site visits revealed the limitations of that approach. Ghost gear is hard to locate, slow to degrade, and often difficult to address with architectural means.

What emerged instead was a new lens. By shifting attention from the gear to the ecosystems it damages, the project gained specificity, clarity, and physical relevance. The ghost forest offered a starting point. The oysters offered a means of healing. Sea level rise offered the urgency and the constraint.

The project became less about control and more about choreography. It became a space where natural processes are given form, and where visitors are asked not only to learn, but to care. The buildings do not impose a narrative. They host one.

Conclusion: A Thesis about Participation, Change, and Resilience

This thesis does not attempt to stop sea level rise. It does not aim to remove every piece of ghost gear from the bay. Instead, it acknowledges that some ecological damage has already occurred, and asks how architecture can move forward from that reality.

The result is a three-part composition of site-specific interventions: a nursery that grows life, a research space that teaches it, and an outlook that honors its return. Together, these buildings respond to a landscape in flux. They do not claim permanence, but they offer presence. They do not fight change, but they help us understand it.

Architecture in the age of ecological uncertainty must work with the conditions at hand. It must be light, legible, and grounded in place. This thesis offers one such possibility, rooted in the rhythms of oysters, the shadows of ghost forests, and the long view of the bay.

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