ABSTRACT

Title of Document:	BLUE CRAB FARMING ON MARYLAND'S EASTERN SHORE
Author:	Justin M Donnelly
Degree:	Masters of Architecture, 2009
Directed By:	Assistant Professor Michael A Ambrose, Chair

Biologists speculate that a combination of pollution and overharvesting might soon lead to the extinction of the blue crab in the Chesapeake Bay. This project investigates inland crab farming as a means by which to resurrect the region's dwindling blue crab industry and alleviate pressure on rapidly declining wild fisheries. Although the project transplants the blue crab onto land, it minimizes the impact to the plants and animals displaced. In short, the project asks us to rethink how we fish and how we farm and how they relate. The architectural proposal seeks to establish the general parameters of a heretofore untried blue crab farming operation and to apply these rules to a specific farm project in Dorchester County, Maryland. The final product consists of a series of greenhoused raceways, constructed wetlands, working meadows, a laboratory for rearing crab eggs to juvenile development, a picking/processing facility, restaurant, and modest educational facilities.

BLUE CRAB FARMING ON MARYLAND'S EASTERN SHORE

Justin M Donnelly

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Masters of Architecture
2009

Advisory Committee:
Assistant Professor Michael A Ambrose, Chair
Associate Professor Brian Kelly, AIA
Assistant Professor BD Wortham-Galvin, PhD

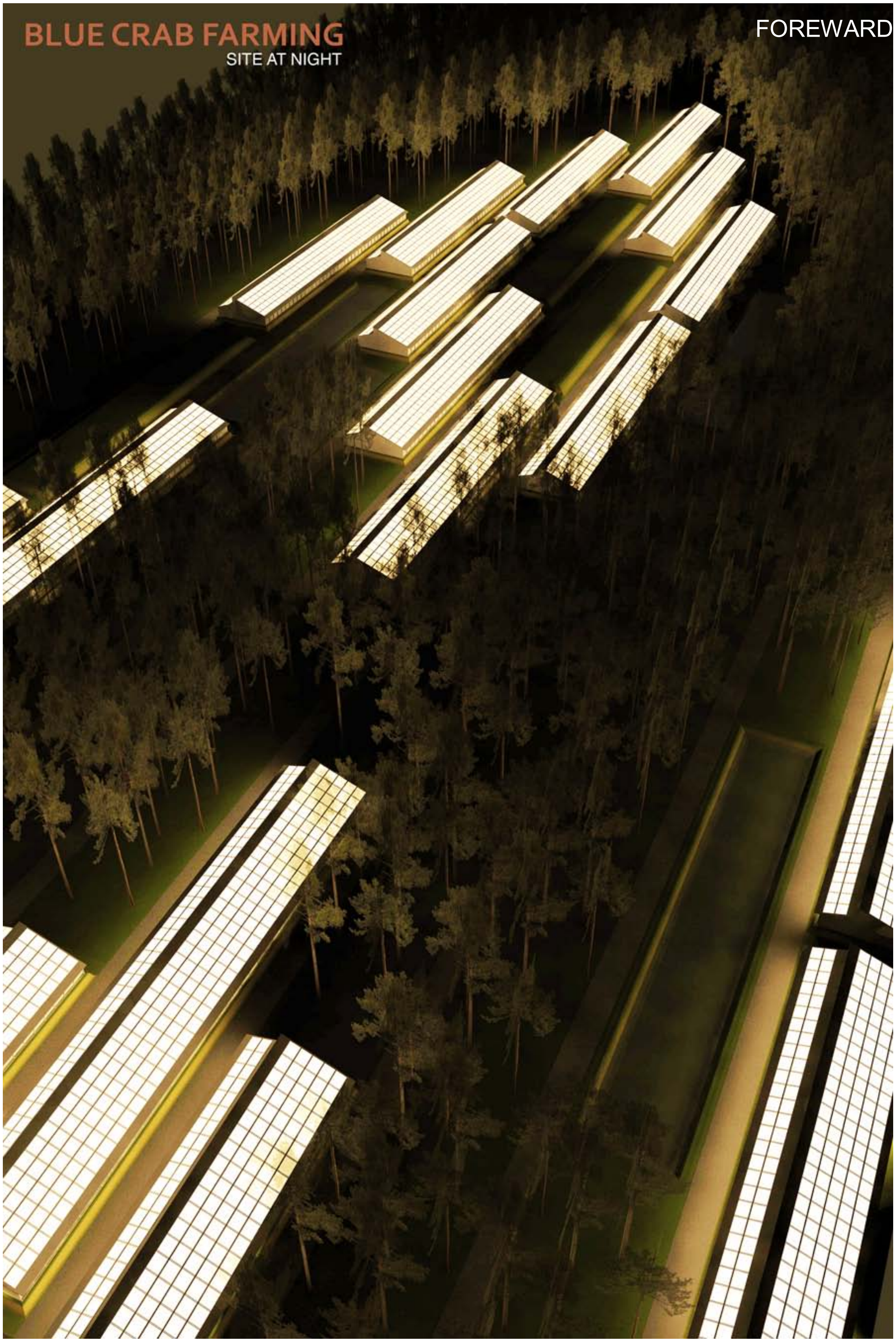


Figure 1 - Aerial Perspective -"Blue Crab Farm at Night." Author illustration.

Humans have farmed a variety of crustaceans since the 1990s, but the blue crab remains an anomaly; it is one of the last foodstuffs to be successfully farmed for commercial purposes. As such, the only way to get a blue crab is to go out into the wild and catch one in its natural habitat. This is unusual among modern animal foodstuffs. Take for instance, the chicken. Can you imagine leaving your home with a net to catch a wild chicken at a game preserve? It is almost unthinkable for the majority of Americans to do anything other than purchase prepackaged chicken produced under the auspices of a large company like Perdue. Think, then, how strange it is that we assume that the crabs we eat are fished for in the wild, and that this form of harvesting is an inalienable right. Unfortunately, the proliferation of this right over time has led to overharvesting that has depleted natural reserves and now threatens to eradicate many species in their entirety.[1]

The potential extinction of the blue crab in the Chesapeake Bay means more than a hole in our regional estuarine food chain. It is yet another domino in the chain reaction that stems from the recent death of the Chesapeake Bay Oyster, and it points clearly to the global threat of mass expeciation, known to scientists as the *Holocene extinction event*[2]. As this is an anthropogenic, or man-made, phenomenon, we have an obligation to countermand the harm we have done thus far. Preserving the heritage of biodiversity will be one of the great challenges for our generation and for those that follow. As such, blue crab farming represents one small effort to shrink mankind's ever-growing footprint.

This project suggests that blue crab farming on the Eastern Shore promises to perform two services: first, to provide locally grown foodstuffs to meet ever-growing regional demand, and second, to alleviate pressure on wild fisheries so the wild blue crab population can rebound in the Bay as the salmon population has in the North Atlantic. As such, the project is framed as a proposition in five parts:

- *i) An introduction to the Chesapeake Bay blue crab and its current plight*
- *ii) A historical overview of the blue crab industry in the region*
- *iii) A general primer on blue crab farming, program, and requirements*
- *iv) An Architectural proposal for a blue crab farm in Dorchester County, Maryland*
- *v) A proposed future for blue crab farming in Maryland*

---

[1] By some estimates, as much as 30 percent of the world's animals and plants could be on a path to extinction within 100 years. http://www.pbs.org/wgbh/evolution/library/03/2/l_032_04.html
[2] Pimm, Russell, Gittleman, and Brooks, *The Future of Biodiversity*, Science 269: 347-350 (1995).

The project employs a single thematic element to unify and amalgamate a thesis of many different parts—the concept of *commensalism*—a two-species association in which there is a positive effect on one species and neither a positive nor a negative effect on the other. While this term is similar to symbiosis, it does not imply a physical relationship, merely a beneficial adjacency. Mankind does not generally participate in commensal associations. In fact, mankind's presence is a general indicator of blight. This thesis suggests that mankind's presence need not entail a parasitic or harmful association. Instead, the project attempts to develop a series of commensal relationships at four levels of increasing specificity:

i) The level of the site

ii) The level of the program and programmatic relationships

iii) The level of the building itself

iv) The level of the architectural details

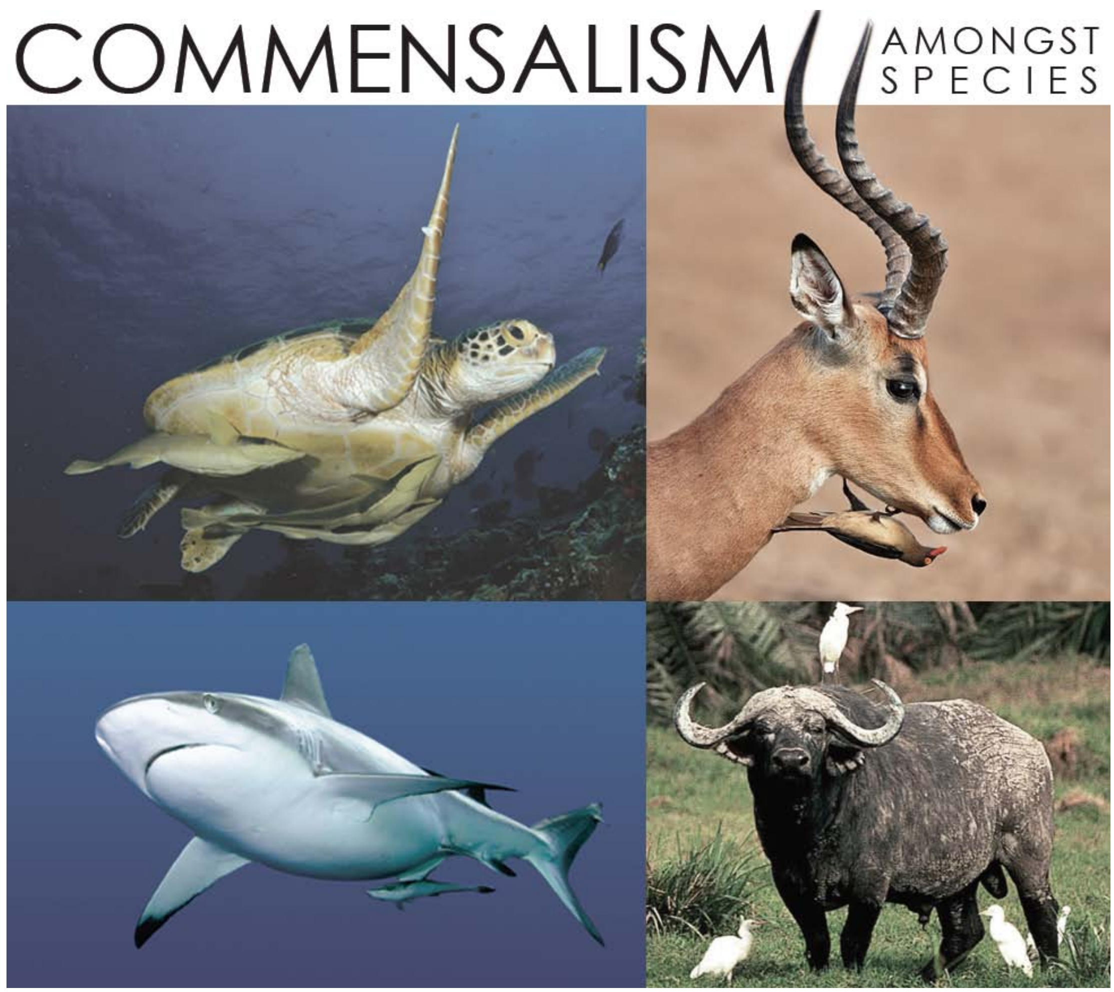


Figure 2 – Commensalism amongst species. Author Illustration.

ACKNOWLEDGEMENTS

I'd like to acknowledge the friends, advisors, and collaborators who helped in nurturing this project from an idea to an architectural proposal. I'd like to thank my committee—BD Wortham, Brian Kelly, and particularly my chair, Michael Ambrose, for their interest, ideas, and support over the course of the past year. I'd like to thank the Kea Professor, Steve Ziger, for his insight into the pragmatic workings of the farm complex, which proved invaluable. I'd like to thank Devin Kimmel for imparting his unique vision of landscape and our place within it. I'd like to thank John Li for sharing his keen and unerring insight into plan/parti, and his incredible facility with image. I'd like to thank William West, Kathleen Flynn, and Michael Fischer for their assistance in getting drawings into and back out of the computer. And finally, I'd like to acknowledge my brother, Andrew Donnelly, for his help and assistance along the way.

CONTENTS

GRAPHICS

INTRODUCTION

M.J. Rathbun, a naturalist from Maryland, first identified the blue crab as a unique species in 1886, when he coined the name *Callinectes sapidus*, or "savory blue swimmer" (fig. 3).[3]

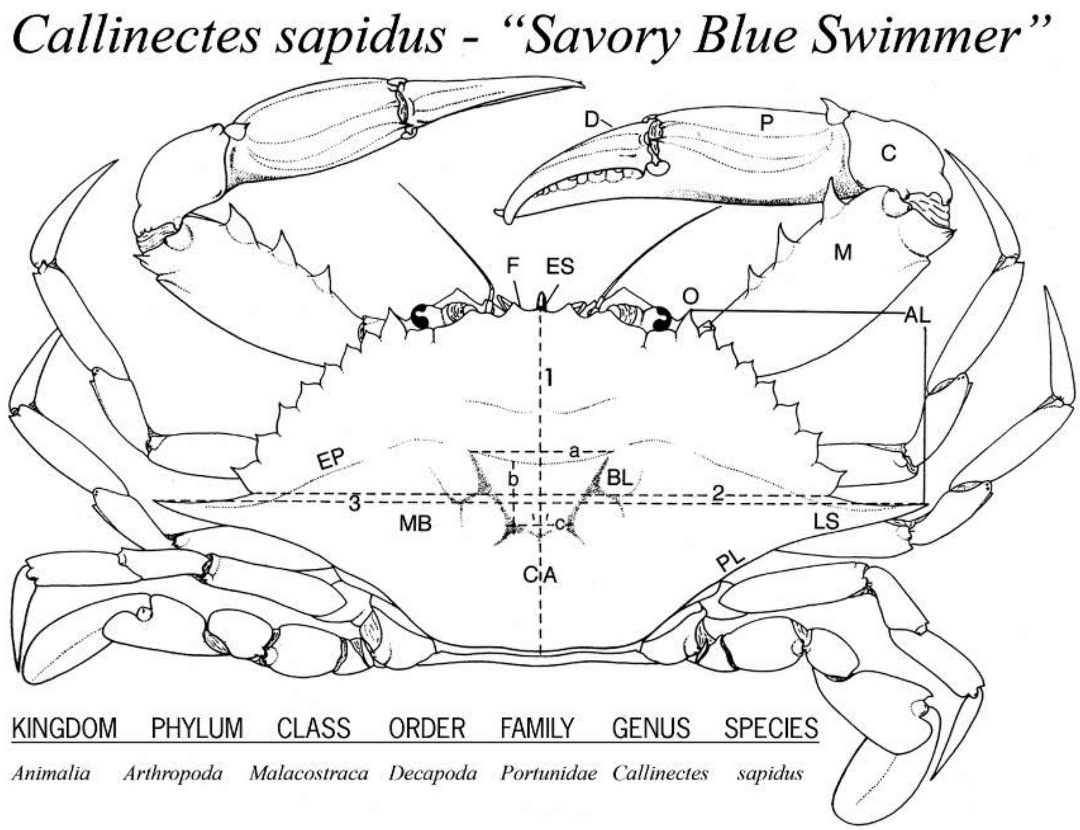


Figure 3- The mid-Atlantic blue crab—Callinectes sapidus. Image Courtesy Kennedy & Cronin.

[3] Kennedy & Cronin—The Blue Crab: Callinectes sapidus, page 656.

Although its evolutionary origin lies in the tropics, the blue crab has adapted to waters of varying temperatures and can be found as far north as Nova Scotia and as far south as Venezuela[4] (fig. 4). The Chesapeake Bay is near the northern limit of blue crab geographic distribution, but the unique estuarine conditions of the Bay have proved so favorable to crab development that the Bay area itself accounts for one-third of all domestic blue crab harvests each year. (fig. 5).[5]

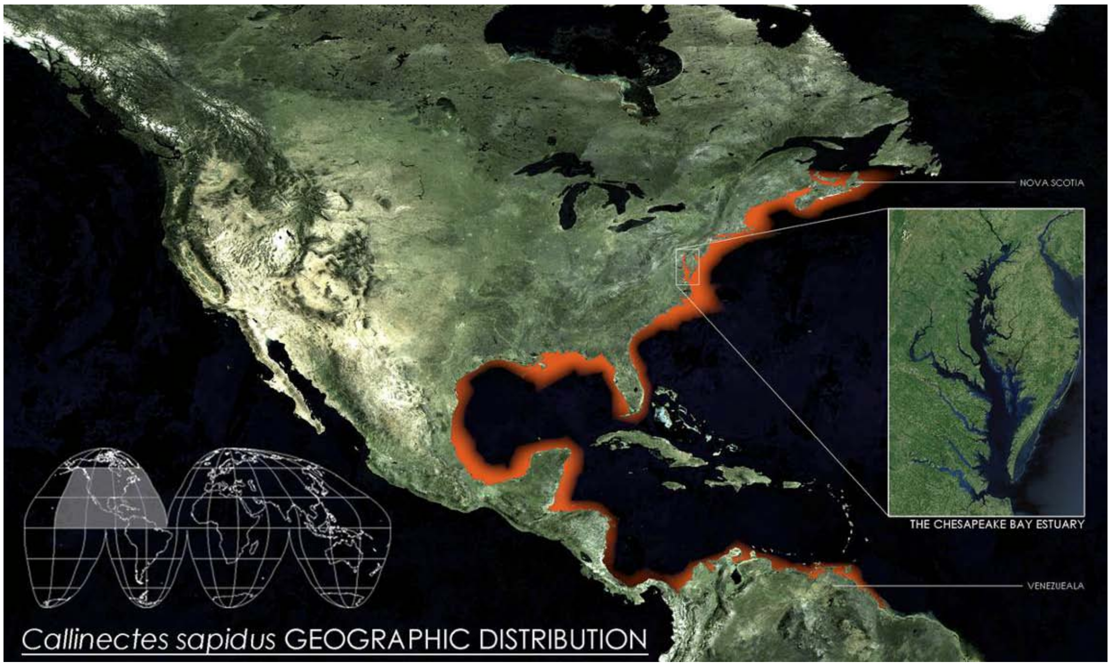


Figure 4- Native geographic distribution. Author illustration.

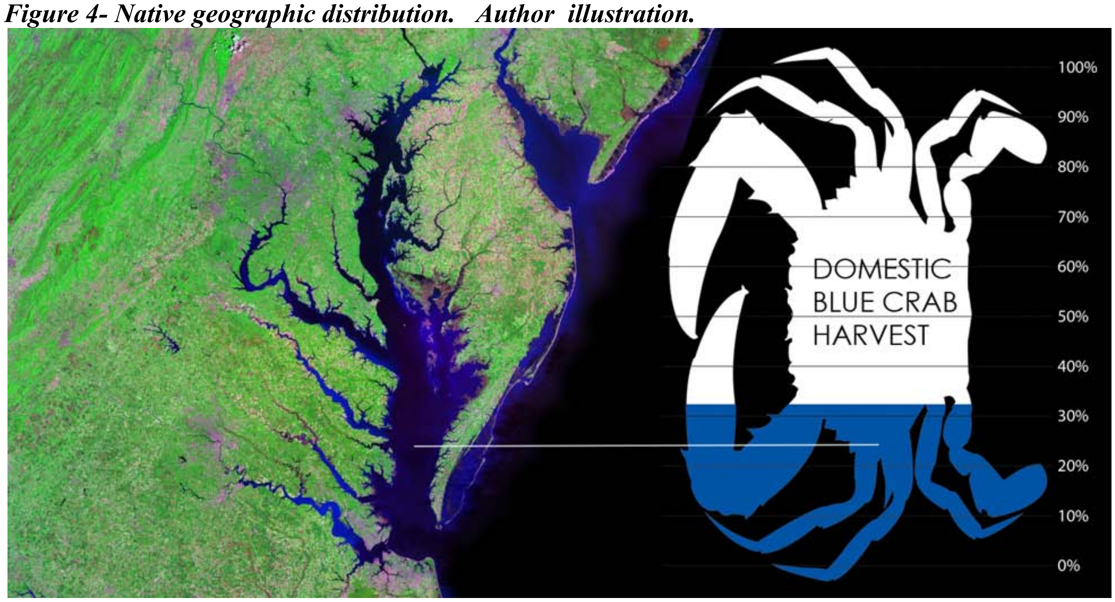


Figure 5 – 33% of Domestic Blue Crab Harvests. Author Illustration. Base Image NOAA Landsat.

---

[4] http://www.serc.si.edu/labs/fish_invert_ecology/bluecrab/overview.jsp
[5] "*Callinectes sapidus*". http://www.sms.si.edu/IRLSpec/Callin_sapidu.htm.

As such, the blue crab's iconic significance to the Chesapeake Bay region has grown over time. Louisiana has its shrimp, New England has its oysters, Texas has its beef barbeque, and in mid-Atlantic has its crabs. "More than any other single foodstuff, the blue crab has come to define this region" (fig. 6).[6]

Figure 6 – Foodstuffs as regional icons. Author illustration.

This is especially true for Maryland, where the blue crab is heralded as the "Maryland State Crustacean." The crab has come to represent more than a foodstuff in our region—it represents an industry, a culture, and a way of life (fig 7).

Figure 7 – Blue crab as generator of regional character. Author illustration.

[6] Washington City Paper, *Crab Imperialist*, July 15–21, 2005, by Todd Kliman.

Given its abundance, history, and regional significance, one would expect that a Maryland crabcake would be chock full of Chesapeake Bay blue crab. Unfortunately, this is rarely the case. When you bite into a Maryland crabcake at a historic Maryland crab restaurant this summer, the odds are that the crabmeat in your sandwich comes from the eastern shores of the Philippines, not the eastern shore of Maryland (figure 8).

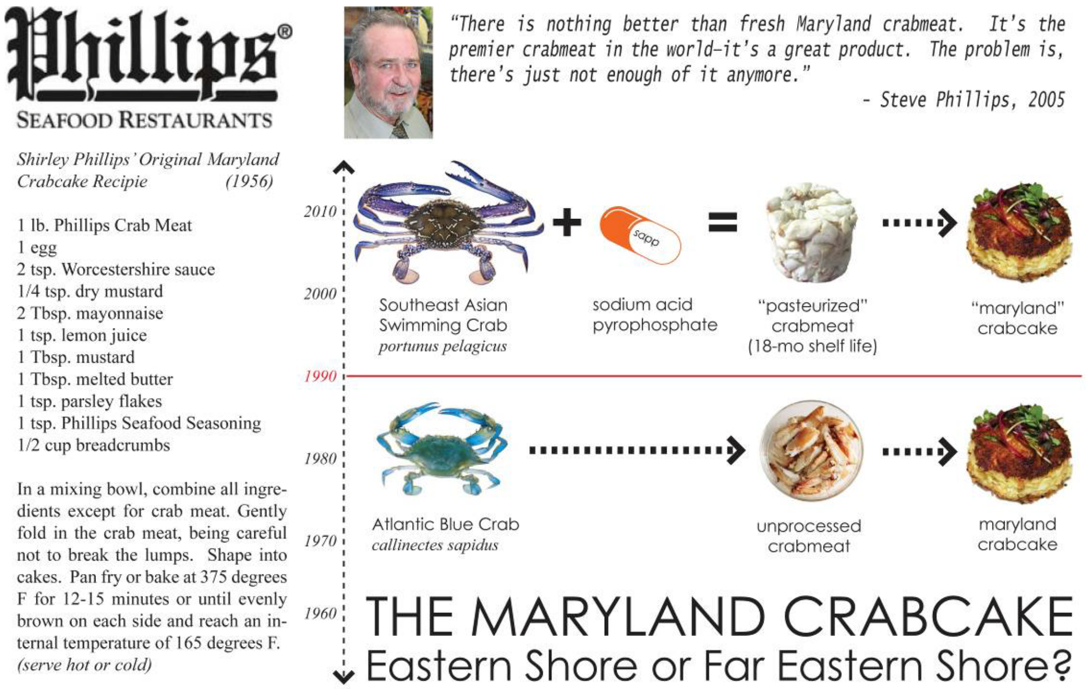
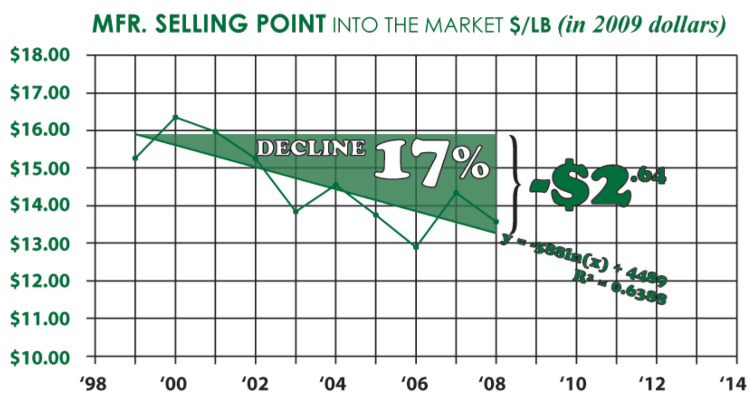


Figure 8 – Eastern Shore or Far Eastern Shore? Author illustration.

Although no one single individual or company is responsible for this lamentable fact, the Phillips seafood story provides valuable insight into the changes the Maryland crabbing industry has experienced over the past century. In 1916, A. E. Phillips founded the Phillips Seafood Company and opened a crab processing facility in Hooper's Island, Maryland. Since that time, the Phillips enterprise has grown considerably. Brice and Shirley Phillips opened the first in a series of seafood restaurants in Ocean City, Maryland in 1956. Over the course of the following four decades, the Phillips family opened restaurants in Baltimore, Washington, DC, and another two in Ocean City. In the 1980s, Steve Phillips assumed the reins of the company, but by the time he was ready make his mark on the family business, the Chesapeake Bay didn't have enough blue crabs to satisfy the scope of Mr. Phillips' ambitions. So he headed to the Philippines, where he had heard that crabbers were harvesting the blue swimmer crab, a distant cousin of the Chesapeake Bay blue crab, with a similar "flavor profile."[7] With the help of a chemical—sodium acid pyrophosphate, or SAPP—the Phillips Company found they were able to preserve the Philippine crabmeat for a period of 18 months, a process the Phillips Company refers to as "pasteurization"—a treatment that both whitens the crabmeat and "tempers" its natural flavor. What the Phillips Company has lost in terms of taste, it has easily recouped in terms of profit. Phillips is now a multinational company that is expanding its market into Europe and beyond.

Steve Phillips is not the only one importing foreign crabmeat. Over the past 10 years, production of local crabmeat has been relatively steady, but there has been a huge increase in imported crabmeat.[8] If demand has increased during the period, it has been more than met by the increase in imports, which have abetted the steady decline in the price of locally harvested blue crabmeat (fig. 9). Low-cost crabbing industries in South America have flooded the market; foreign crab can be caught, processed, preserved, shipped, distributed, and sold for considerably less than local blue crab can be caught and processed (fig. 10).



YEAR	CRABMEAT $/LB	CRABMEAT 2009 $/LB
1999	$ 11.79	$ 15.26
2000	$ 13.05	$ 16.35
2001	$ 13.11	$ 15.97
2002	$ 12.72	$ 15.25
2003	$ 11.81	$ 13.84
2004	$ 12.74	$ 14.55
2005	$ 12.45	$ 13.75
2006	$ 12.05	$ 12.89
2007	$ 13.78	$ 14.34
2008	$ 13.55	$ 13.57

Figure 9 - Real Cost of Crabmeat Processed in Maryland (Domestic Harvest). This is the Manufacturer's Sale Price into the Wholesale Market in $/lb, Converted to 2009 Dollars. Data courtesy of Doug Lipton, Professor, UMD Sea Grant Extension Program. Author illustration.

Figure 10 – Relative cost of crabmeat in Maryland. 2005 wholesale price. Author Illustration.

---

[7] Washington City Paper, *Crab Imperialist*, July 15–21, 2005, by Todd Kliman.
[8] From author's 8.12.09 email correspondence with Doug Lipton, Associate Professor, Department of Agricultural & Resource Economics, Program Leader, University of Maryland Sea Grant Extension.

All of this doesn't change the fact that the mid-Atlantic blue crab just seems to *taste better* than any other type of crab, whether from the Philippines or Venezuela. In a 2005 blind taste test featuring top area chefs, local blue crab was picked from amongst its Philippine and Venezuelan peers 100% of the time.[9] There is therefore a value to that taste, even if local businessmen have been struggling to realize it.

Jack Brooks, Managing Director and Owner of JM Clayton Seafood Co., Maryland's oldest and most esteemed crab picking and processing company, speculates that the distinct and flavorful taste of Maryland blue crab derives in part from the brackish waters of the Chesapeake Bay. He claims to be able to locate a crab within a few miles of where it was caught by its taste alone. But Brooks remains convinced that it is the cold temperature of Maryland waters that define the flavoring process: "When a Maryland blue crab burrows into the mud to hibernate for the winter, it stores up fat that will keep him warm all winter long."[10] According to Brooks, this fat content is responsible in large part for the unique flavor of the Chesapeake Bay Crab. Brooks points out that blue crabs from Venezuela do not have the same taste as crabs from our local waters. Brooks therefore surmises that it is the overwintering process and consequent fatty deposits that imbues the Chesapeake Bay blue crab with its unique flavor.

The jury is still out on this issue. Recent research conducted at the University of Maryland's Biotech Institute shows that blue crabs can grow to full size within six months of the juvenile stage.[11] It is believed that with the proper environmental stimulants, this time could even be cut in half. This finding might serve to contradict Brooks' line of reasoning regarding the overwintering process as source of regional flavor, particularly if crabbers are harvesting full-size crabs that have not overwintered once. If this is the case, then the mustardy taste of the Chesapeake Bay blue crab is probably due to the brackish Bay water and local estuarine food sources.

---

[9] Washington City Paper, *Crab Imperialist*, July 15–21, 2005, by Todd Kliman.

[10] Author's interview of Jack Brooks, managing director of The JM Clayton Co, conducted July 2, 2009.

[11] Interview with Dr. Yonathan Zohar, COMB Director, and Odi Zmora, COMB Master Nutritionist, conducted 02.12.09.

The increasing paucity of blue crab is due to the dramatically declining regional crab harvests that by some estimates have declined by 65% over the past fifteen years.[12] This decline should not, perhaps, be totally unexpected. Commercial fish harvests, such as that of the rockfish, have been declining in the Bay for some time. But what is more telling is the near eradication of the Chesapeake Bay oyster, one of the blue crab's most basic food sources (fig. 11).

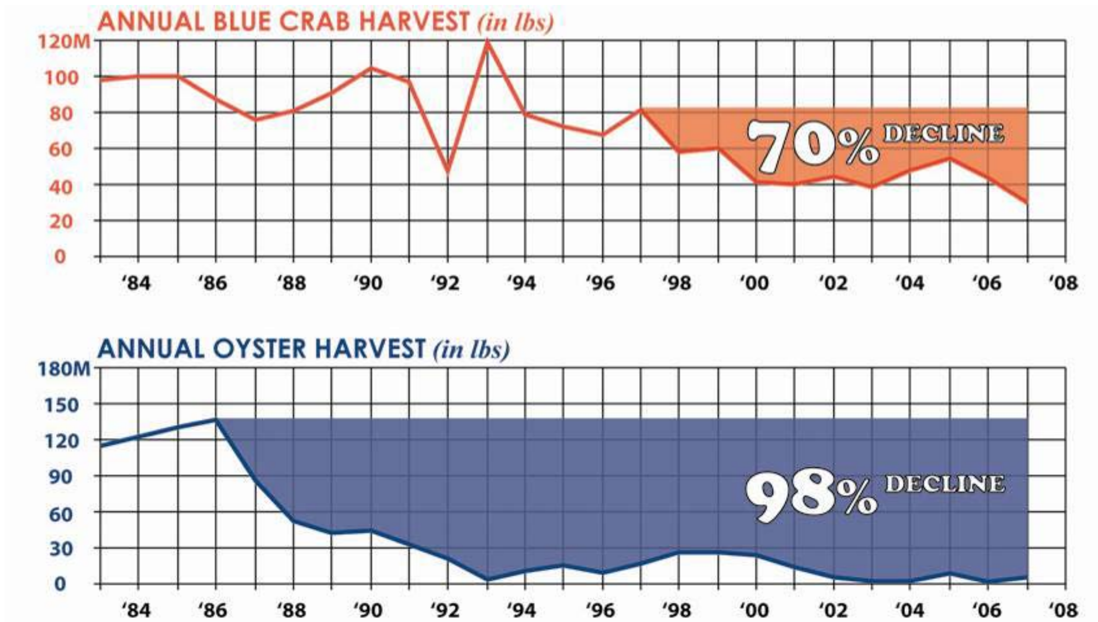


Figure 11 – Annual blue crab & oyster harvest in the Chesapeake Bay. Author illustration. Data courtesy http://www.washingtonpost.com/wp-srv/metro/interactives/failingthechesapeake/

As a result of this decline, Maryland is witnessing the demise of an industry, a tradition, and a marine culture. Professional watermen have been forced to abandon their profession along with the seasonal employees who pick up work at the processing facilities that once lined the Eastern Shore. A way of life unique to Maryland is disappearing.

THE CHESAPEAKE BAY BLUE CRAB'S LIFE & PLIGHT

There are four primary causes behind the degradation of the Chesapeake Bay and the consequential habitat loss accompanying this degradation. They are listed below in order increasing significance:

GHOST POTS—There is consistent debate over whether old crab pots abandoned on the floor of the Bay are killing the blue crab. The realistic answer is most likely "No."

---

[12] Doctor Yonathan Zohar, director of UMBI, quoted in The Scientist.com V 23, Issue 2, pg 27. By Megan Scudellari.

FOREIGN SPECIES—The introduction of foreign species has severely impaired the Chesapeake Bay ecosystem. The failed plan to rejuvenate the flagging Bay oyster population with an Asian oyster ultimately resulted in the extermination of the Chesapeake Bay oyster.

OVERHARVESTING—Maryland watermen have consistently overharvested the Bay. In recent years this led directly to the extinction of the Chesapeake Bay oyster, and soon it may lead to the extinction of the Chesapeake Bay blue crab. State legislation has sought to restrict crab catches in terms of size and sex, but many believe these restrictions are too little.

INDUSTRIAL POLLUTANTS—Maryland has worked to reduce industrial pollution into the Chesapeake, and has made some real gains, but the fact of the matter is that the Chesapeake Bay can no longer support any industrial pollution given the exponential growth of residential and agricultural pollutants over the past decade.

RESIDENTIAL POLLUTANTS—As the Eastern shore has changed demographically from a farming community to a waterfront resort community, residential construction has increased exponentially. Because much of this land is unincorporated and has a high water table, developers have been installing septic fields for each new housing development. With high water tables and saturated ground, the wastewater from these new developments sluices directly into the Chesapeake—causing enormous damage to Bay plant and animal species.

AGRICULTURAL POLLUTANTS—EPA officials claim that agriculture is the largest single source of pollutants and sediment in the Chesapeake Bay, accounting for over 40 percent of the nitrogen and phosphorous and over 70 percent of the sediment. State officials say that animal manure produces more phosphorus and nearly the same amount of nitrogen pollution as all human wastewater from treatment plants in the state combined.[13] And although the dairy and hog industry in states adjacent to the bay produce more pounds of manure per year, poultry waste has more than twice the concentration of pollutants per pound. Thus it is fair to say that chicken farming, one of Maryland's biggest and most lucrative of agricultural industries, is also one of the Bay's worst enemies.

These last 3 causes of degradation—industrial, residential, and agricultural pollution accumulate each year to cause vast dead zones in the Bay. These areas are vast tracts of water that have been entirely depleted of their dissolved oxygen content by algae (fig. 12, overleaf). Although the science behind this phenomenon has been understood for some time, it has been exceptionally difficult to find the political will to do anything about it, and dead zones remain one of the most menacing threats to the Bay's present and future health.

[13] www.nytimes.com/2008/11/29/us/29poultry.html?pagewanted=2&_r=1

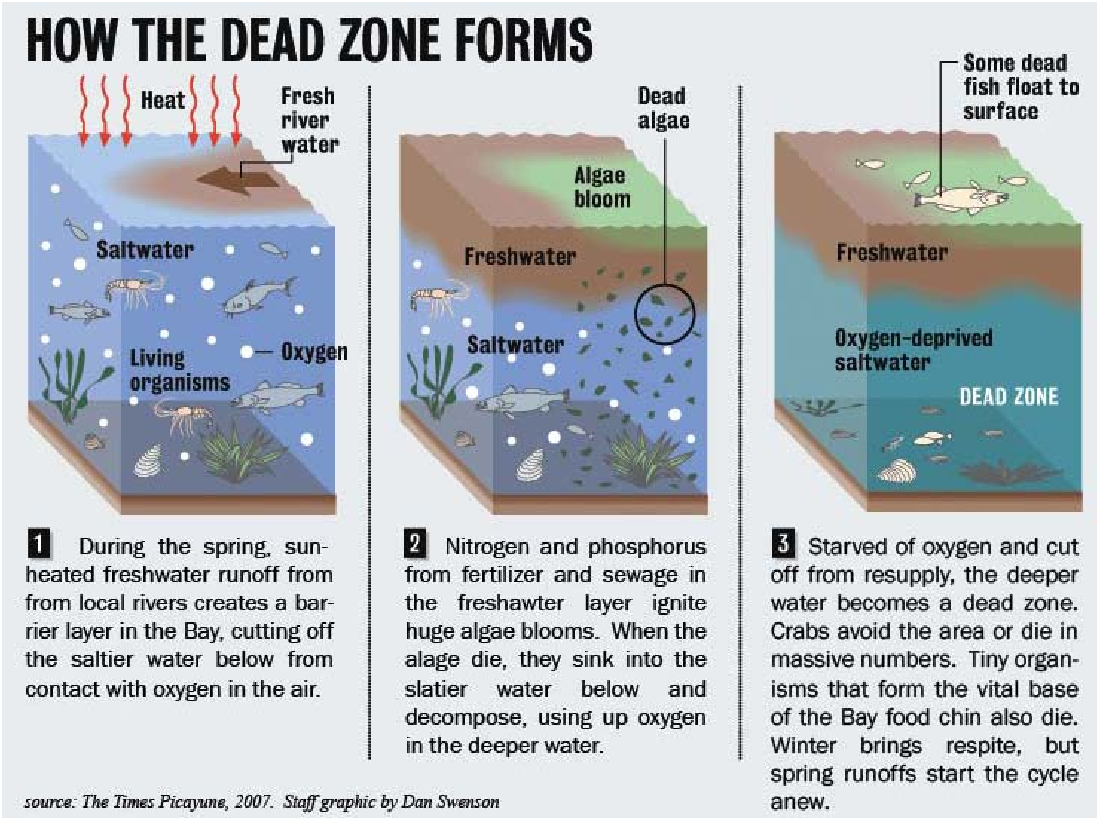


Figure 12 – ***How the dead zone forms. Courtesy of The Times Picayune, 2007, Dan Swenson. http://blog.nola.com/graphics/deadzone_how061007.gif***

Since crabs require a relatively low dissolved oxygen content of 3 milligrams/litre, they have a better chance of survival in oxygen depleted water than do some larger fishes. That said, with ¼ of the Bay dead, even the crab cannot escape the effects of asphyxiating waters (figure 13).

Figure 13 - Crabs scramble to escape oxygen depleted waters on the western shore. Image courtesy of the Chesapeake Bay Foundation's Report on Bad Water and the Decline of Blue Crabs in the Chesapeake Bay, December 2008. cbf.org/badwaters

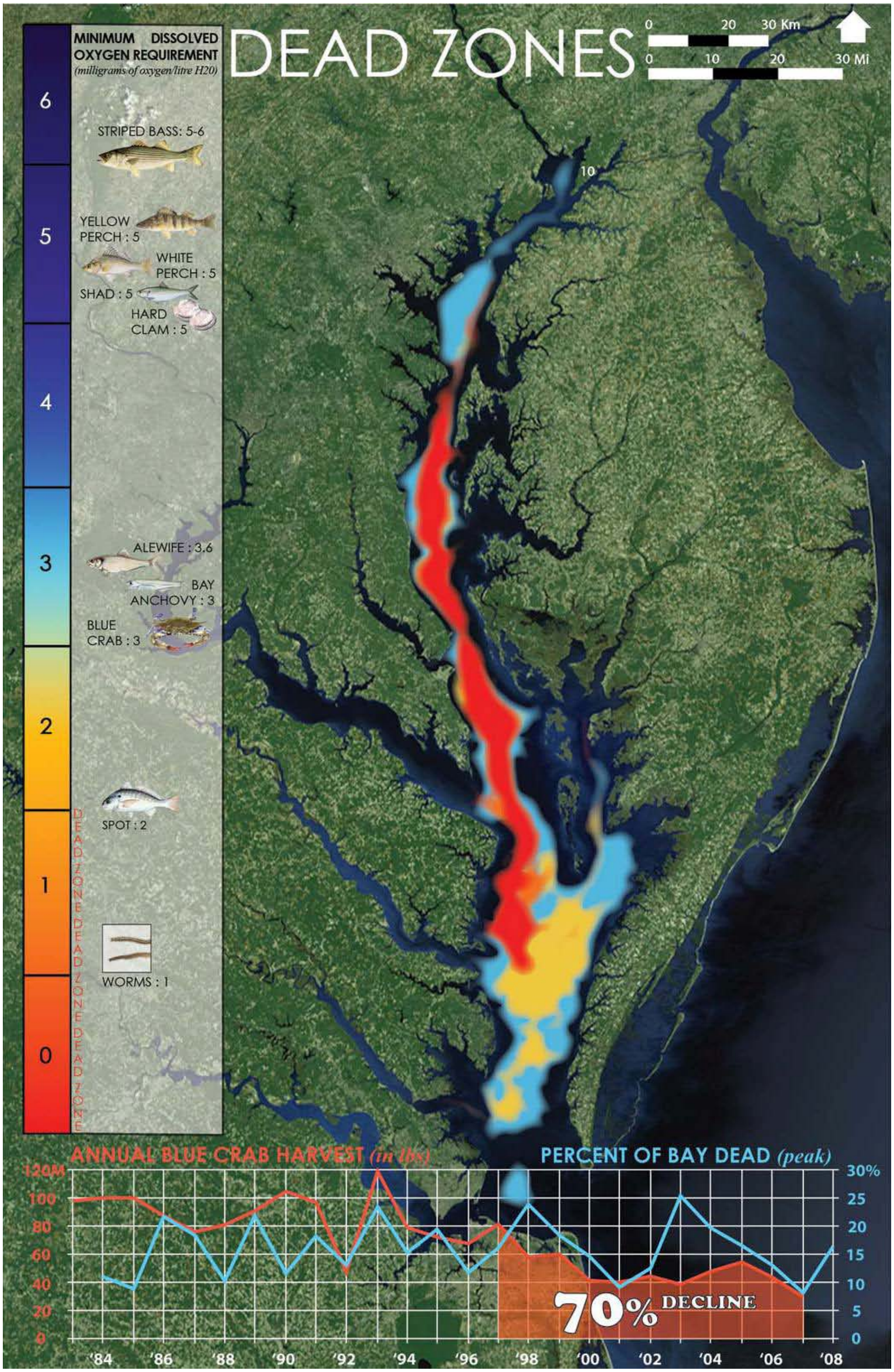


Figure 14 – Dead zone distribution alongside dissolved oxygen requirements. Author illustration.

Because blue crabs lead a migratory lifecycle, they are doubly susceptible to the lethal threat posed by the dead zones. Blue crab eggs require a minimum of 20 parts per thousand (ppt) salt content to survive, but blue crab larvae require closer to 30 ppt. Sea water is 36 ppt. Juvenile blue crabs can survive in waters with as little as 3 ppt salt content, and prefer defensible environments (not the open sea) for camouflage and greater food availability. As a result, the blue crab migrates up the bay to estuarine environments that afford ample opportunities for food and protection. The slow progress up the bay (blue crabs move an average of 705 feet per day) is doubly perilous due to the extent of the dead zones facing the crabs (fig. 15).

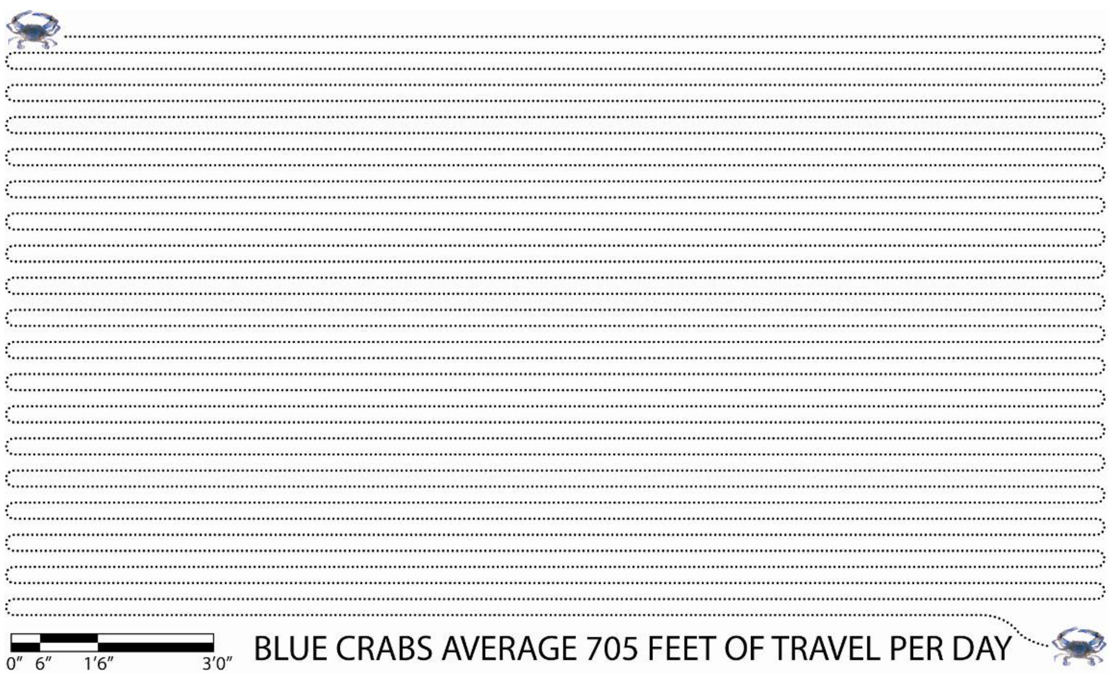


Figure 1135 – Blue crab travel distance per day. Author illustration.

While blue crab males make the trip up the Bay only once, Blue crab females must make the trip thrice—once up for growth and mating, once down while eggs are brooding (14-17 days), and then up again to live out the remains of their three-year lifespan. While males mate many times, the female blue crab mates only once. Of the two-to-eight million eggs she can deliver for spawning, only 1% of the brood is expected to survive long enough to mate upstream and make the trip to the breeding grounds adjacent to Hoopers Island. After the eggs have hatched, the crab emerges as larvae, and evolves through seven zoeal stages over a course of thirty to fifty days. Subsequently the crab goes through one postlarval stage, that of megalopae, over a course of 6-58 days. Once the crab reaches what scientists call the juvenile state, it begins a process of feeding, molting, and northern progression that will lead to adulthood (fig. 16).

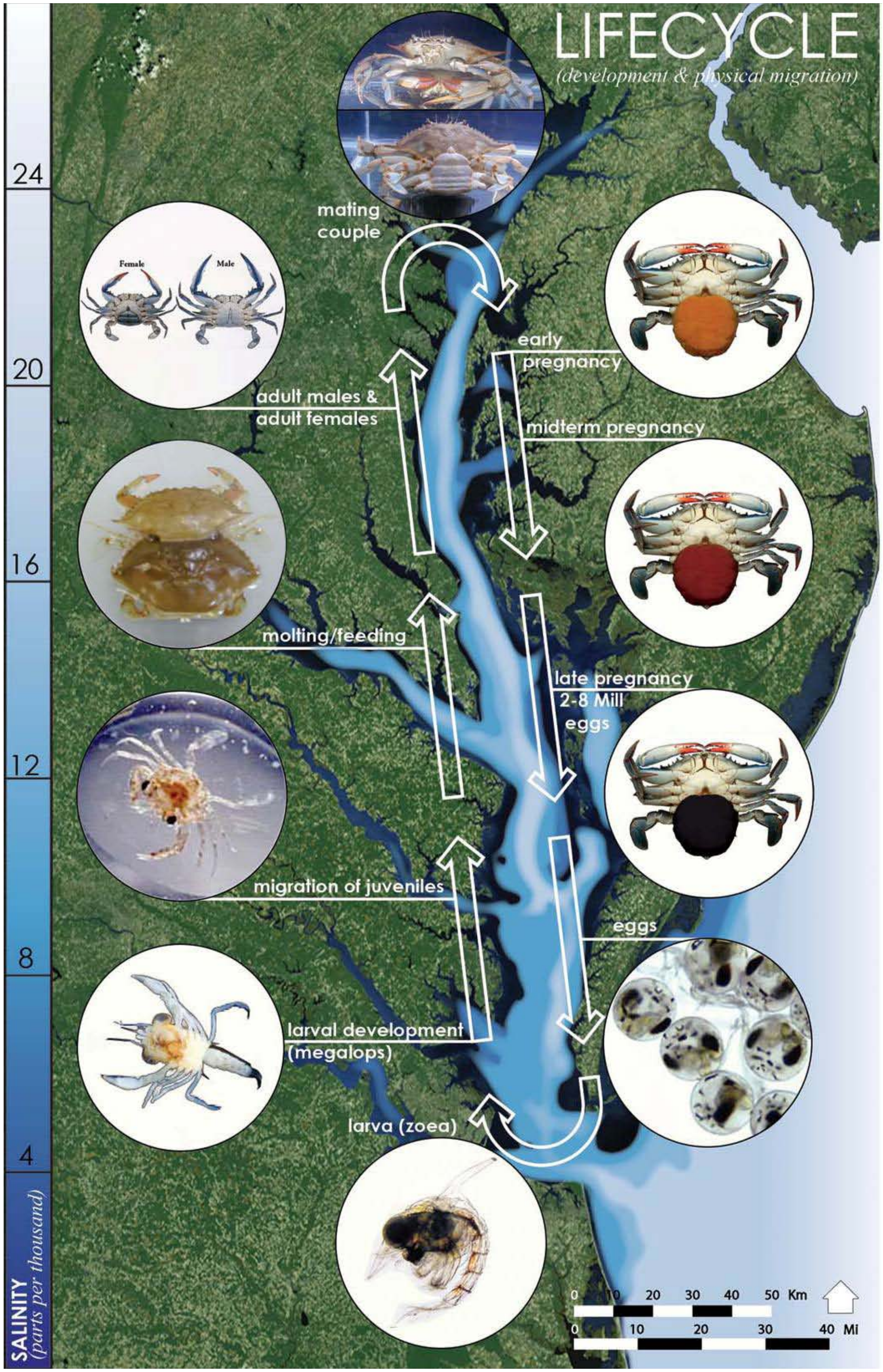


Figure 16 – Blue crab lifecycle mapped against Chesapeake Bay salinity. Author illustration.

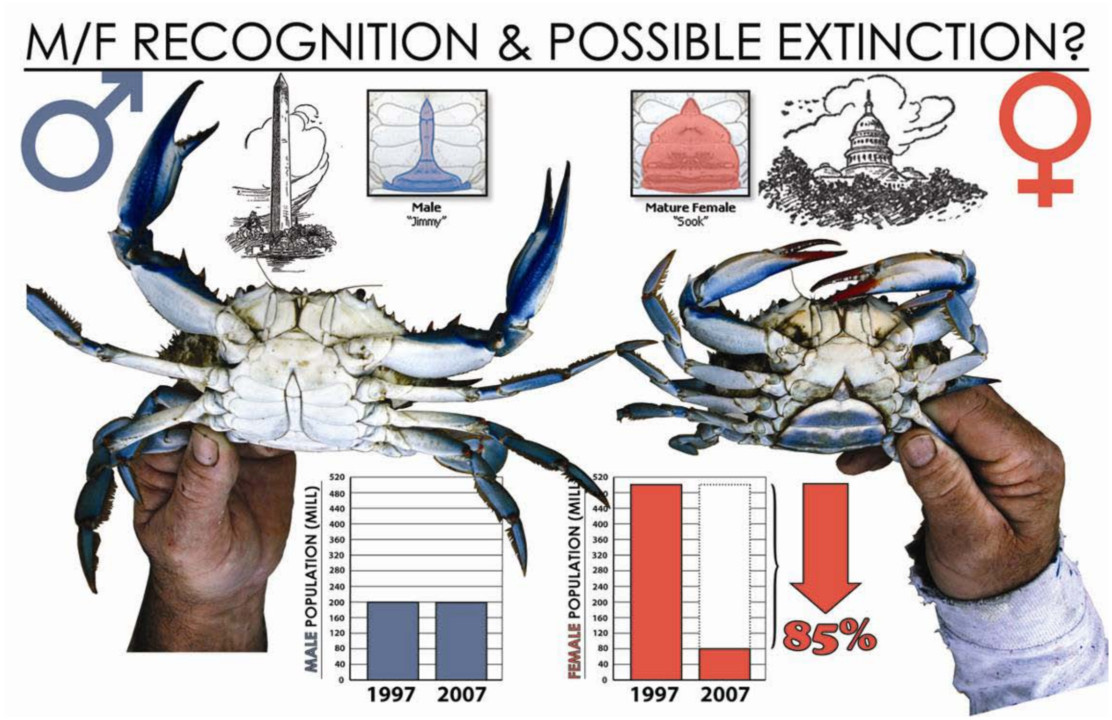


Figure 17 – Population decline by gender. Author illustration.

Given this migratory lifecycle, it is no coincidence that the heart of the Maryland crabbing industry is located adjacent to the blue crab's spawning grounds. This also may account for the marked decrease in the female population relative to the male population over time (figure 17). Given the threats of overharvesting, dead zones, and habitat degradation, it may come as a surprise that blue crabs are not farmed. Fish farming became widely practiced in the early 1990s. Couldn't the same principles be employed to raise and produce crabs as a local commercial foodstuff?

The answer is that up until very recently, it was assumed that crabs could not be farmed like fish. The reason for this assumption is twofold. As a crustacean, blue crabs possess a hard exoskeleton made of chitin. This exoskeleton protects the crab from predators, but it is also imposes limitations on growth. In order to grow in size from a juvenile crab to a fully grown adult, the crab must molt—evacuate its hard exoskeleton and inflate its body with water while it waits for its exoskeleton to harden with the body in its bloated state. While the molting process does not take long (½ hour to 3 hours), the crab's new shell will not harden for 24-36 hours, during which time the crab is known as a soft-shell and is incredibly susceptible to predators. This is not a one-time process. The blue crab molts an average of 27 times on its way to adulthood (figure 18).

Figure 18 – molting and cannibalism. Author illustration.

Most crustaceans display greater and lesser degrees of communal behavior. Lobsters, for instance, are communal creatures that protect members of the school when they molt. The blue crab exhibits the opposite behavior. The blue crab is a fierce cannibal and appears to prefer the taste of its own kind to that of any other food source.[14] As such, crabs invariably attempt to benefit from their siblings' brief moments of weakness after molting. Behaviorally, the blue crab is also hyper-aggressive, far more so than any other crab species. This fatal combination makes the survival rate for blue crabs very slight indeed (fig. 19).

Figure 19 – Agression Scale. Author Illustration. Information provided in 04.08.09Williams Interview.

[14] Author's interview with Odi Zmora, master crab nutritionist at COMB, conducted 02.12.09.

To further complicate matters, the blue crab emits a pre-molt pheromone that entices any nearby blue crabs to come feed. This counterintuitive natural process is directly related to the blue crab's mating process. At 12 to 18 months, the female blue crab is fully grown and ready to mate. When she reaches this point, she releases a pheromone in her urine which attracts males of the species. Prior to this final, "pubertal" molt, males will compete for the right to mate with her, and the selected mate will protect the female (referred to as "cradle carrying") until molting occurs. After this final molt, while the female's shell is still soft, the pair will mate. During mating, the female stores the male's sperm in sac-like receptacles so that she can fertilize her eggs at a later time. Once the female's shell has hardened, the male will release her and the female will migrate to higher salinity waters for spawning. [15] She will spawn two to nine months after mating and will release 2 to 8 million eggs, of which less than 1% will be expected to survive to maturity.[16]

Recently the viability of rearing blue crabs to adulthood in confined spaces has been a topic of some debate. At the University of Maryland's Biotech Institute's Center of Marine Biotechnology (COMB) in Baltimore, scientists have been developing general outlines of the attrition rates associated with captivity. Based upon current market value, a mortality rate of upwards of even 95% could potentially be profitable.[17] At COMB, scientists are working diligently to determine a method of synchronizing the blue crab's molt. If an entire population of blue crabs were to molt at the same time, its believed that self-inflicted mortality rates would decline exponentially. And while it is not practiced in the US, crab farming has become a viable and lucrative industry in many other parts of the world even without synchronized molting.

[15] http://www.bluecrab.info/lifecycle.html
[16] http://www.tpwd.state.tx.us/huntwild/wild/species/bluecrab/
[17] Author's interview with Odi Zmora, master crab nutritionist at COMB, conducted 02.12.09.

FARMING THE CRUSTACEAN

While it is commonly believed that the crustacean is the last phylum of animal to be farmed for human consumption, this belief is not grounded in history. Norway boasted several lobster farms that were operational from the 1650s onwards. As such, Norway supplied the courts of Western Europe with lobster until the 1930s. One such example is the lobster farm complex in Espavaer, Norway (fig. 20).

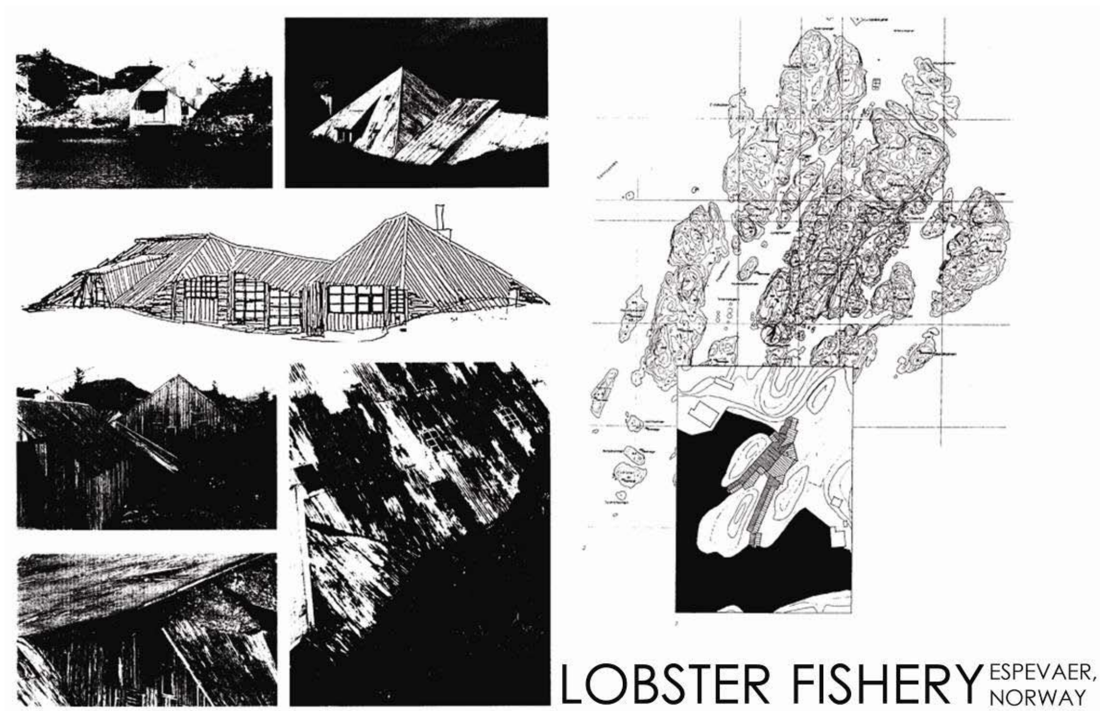


Figure 20 – Lobster fishery in Espavaer, Norway.

This particular facility employed an irregular truss system to span three inlets of a nearby river such that the lobsters could be brought in and the points of entry dammed off. Using fire to heat the enclosed airspace, temperatures could be maintained within the structure throughout the winter months. The plan of this structure is surprisingly contemporary, and the amorphous shed roof is driven entirely by the topography of the peninsula (fig. 21). While this particular project is quite compelling as an idea and a structure, it is probably not the right approach for a Chesapeake Bay crab farming operation. We'll investigate why in turn, but to begin with, we'll a make a brief survey of what types of crab farming operations are working and where.

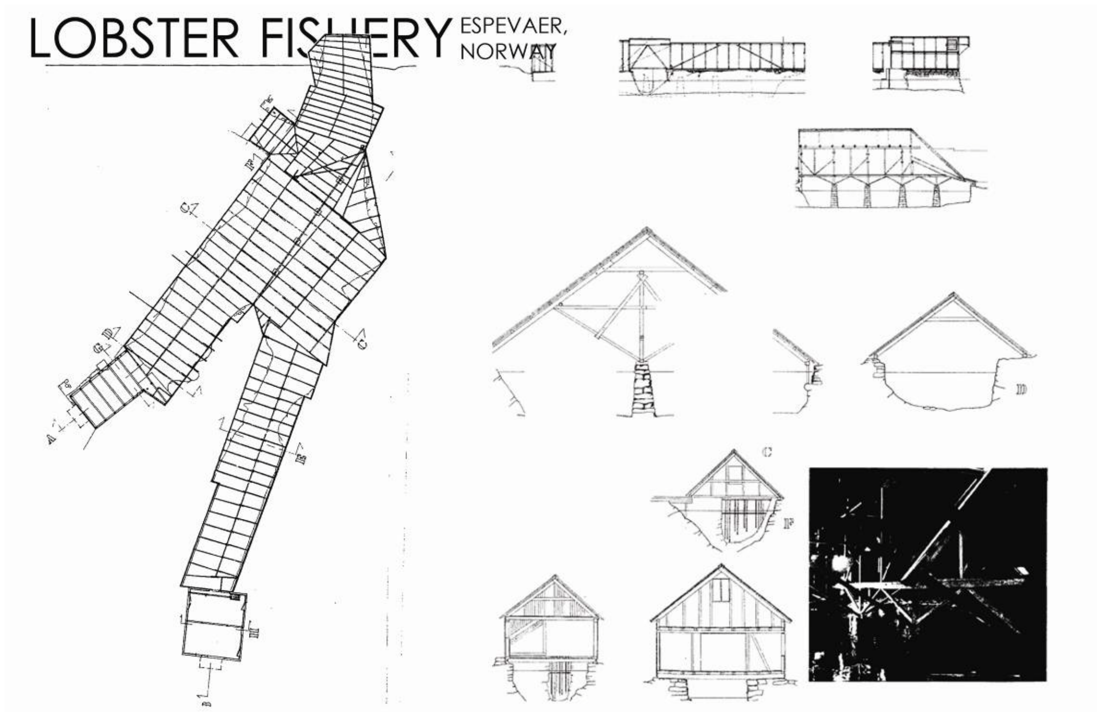


Figure 21 – Lobster fishery, Espevaer Norway1650-1950.

CRAB FARMING ABROAD

While *Callinectes sapidus* has yet to be farmed, the past 10 years have seen an explosion of crab farming with other species in Asia, Australia, and to a lesser extent Europe. Asian crab farming is the furthest developed in size and scope of operations as well as the metric tonnage of crabmeat produced each year. Asian farms run the gamut from low-tech, pond-based farming to hi-tech, submersible cage facilities (figure 21). In pond-based farming operations, crab juveniles are caught in local waters (typically mud flats, or mangroves), and transplanted into closely monitored pond systems for rearing to adulthood. A combination of semi tropical temperatures, cheap land and labor make pond rearing an incredibly economical farming operation for much of southwest Asia. Cage systems require a significant amount of capital investment, but they have proven that they are equally viable in producing a large biomass within a small area earning good profit.

Figure 22 – Different types of crab farming currently practiced in Asia. Author illustration.

CRAB FARMING AT HOME

Recently, an experiment conducted in Swansboro, North Carolina has given some hope to Midatlantic crab farming proponents. In the summer of 2008, NCSU professor Dr. David Eggleston partnered with scientists at the University of Maryland who supplied him with a stock of some 30,000 juvenile crabs. Dr. Eggleston mowed the lawn of his dormant 10 acre farm irrigation pond and filled it with North Carolina tap water (3 ppt salinity). Two months after Dr. Eggleston had introduced the juvenile crabs to the pond, they had grown from ¼ inch juveniles to six-inch adults, “larges” on the scale.

Figure 23 - Size Chart. http://www.marylandbluecrabexpress.com/blue-crab-sizing-chart.html

With an attrition rate of 80%, Dr. Eggleston had roughly 6,000 mature crabs at the end of the summer—an $18,000 harvest. Assuming the rapid growth rate measured in Eggleston's pond could be maintained for more than 1 season, a farmer could raise two to three crops per year. Eggleston is succinct: "There is tremendous economic potential."[18] Given Dr. Eggleston's project as a model, it would seem that blue crab farming is an economically viable proposition. What is more, there is so very much regional interest in the fate of the Chesapeake Bay blue crab, that political and capital interests will no doubt align to make crab farming a viable form of agriculture in Maryland very soon.

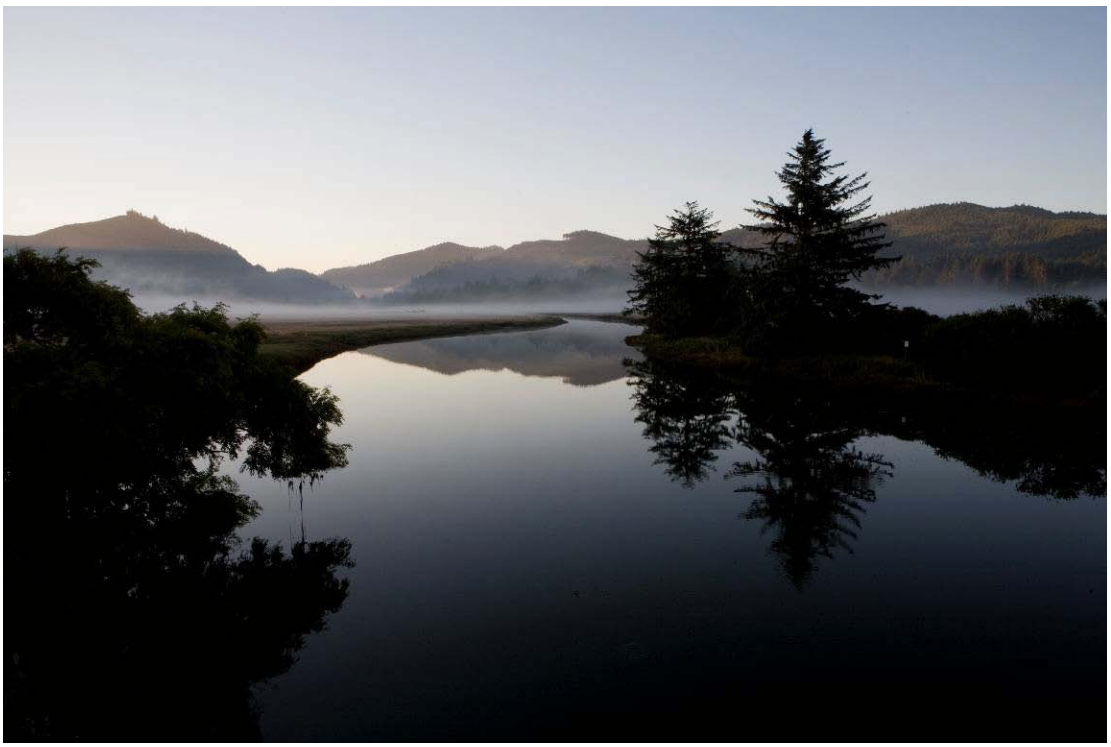


Figure 24 – Dave Eggleston's 10-Acre crab pond in Swansboro, NC. Author's Visualization.

[18] The Scientist, Oct. 2008

TYPES OF CRAB FARMS

The past 20 years has seen the evolution of several types of fish farming methods running the gamut from rustic to hyper-technical. Each of these methods has a particular set of advantages, drawbacks, and challenges that are for the most part directly applicable to crab farming practices. The first type of aquaculture is extensive—relying on photosynthetic processes and self-sustaining/self-regulating systems. The second type of aquaculture is intensive—a system of artificial habitats that rely on feeding and filtration systems in order to function. Extensive aquaculture has little to no environmental impact, but requires large tracts of land and significant labor for harvesting. For this reason, it is reasonable to assume that areas like the Eastern shore (where land comes at a premium and labor is comparatively expensive) are unsuited to extensive aquaculture. In contrast, intensive fish farming can be performed in smaller areas and at greater densities, minimizing land and labor, but the environmental impacts of these techniques can be significant (fig. 31). Intensive aquaculture projects use upwards of a million gallons of water per acre (about 1 m^3 of water per m^2) each year.[19] If this water is not treated and reused onsite, it can lead to significant environmental degradation.

[19] McLarney, William. *Freshwater Aquaculture: A Handbook for Small Scale Fish Culture in North America*.

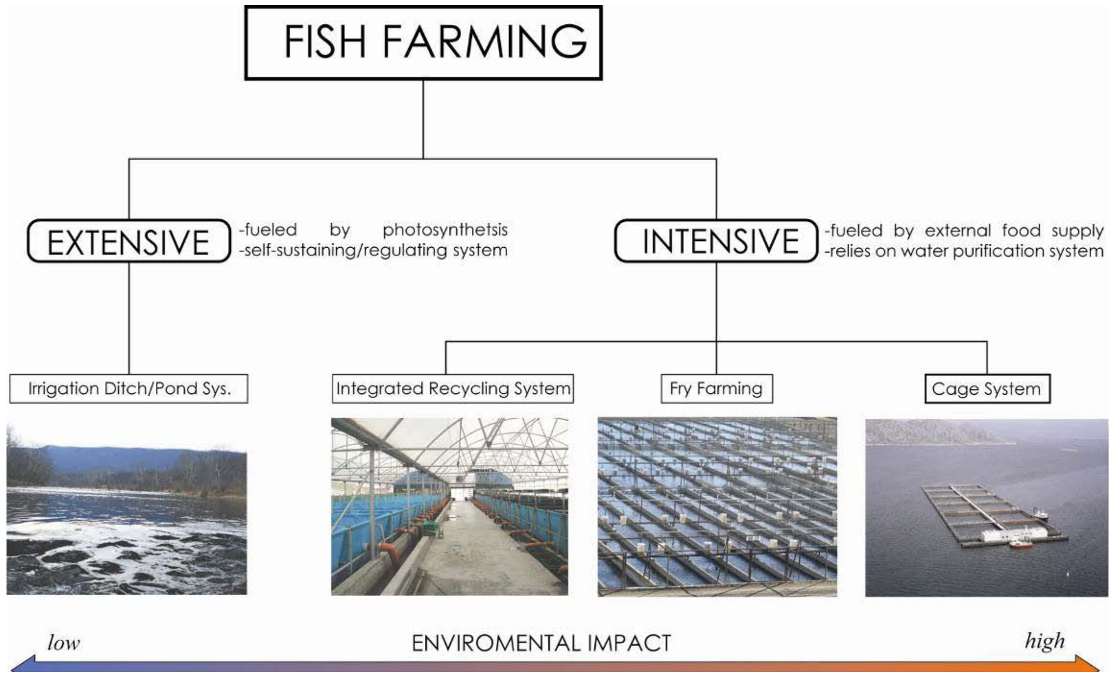


Figure 25 – Types of fish farming mapped against environmental impact. Author illustration.

IRRIGATION DITCH/POND SYSTEMS

Irrigation ditch/pond systems are the oldest and most basic type of fish farming. These systems essentially duplicate a fish's native habitat on an inland site. The pond contains a full predator/prey ecosystem, and is carefully balanced in terms of the flora and fauna present at any given time. The pond system must be quite large because it is designed to support a higher density of livestock than would be common in a naturally occurring biosystem. As global real estate goes up in value, and water resources are constrained, it is likely that the ditch/pond systems will over time give way to more intense forms of aquacultural production.

FRY FARMING SYSTEMS

Fry farming is a practice that has been used since the early 17th century. It essentially consists of culverts that channel water and fish from a nearby stream or body of water and allow these fish to grow up in a closed system supplied with an abundant artificial food source. These fish frys are typically concrete raceways, and can be cleaned by sluicing clean water into the system once the fish have grown to maturity and have been harvested. The great density of fish in these systems has proven a sticking point in the past. Disease and parasites are common, and entire crops can be lost without any warning. What is worse, the effluent from fry farming is invariably sluiced back into the water source albeit downstream from the inlet. This is problematic for obvious environmental reasons.

CAGE SYSTEM

Cage farming is the most toxic of the three types of intensive fish farming. It consists of large cage or net system in which fish are kept in super high densities. The cage is located in open waters such that the system is guaranteed a constant supply of freshwater (fig. 26). Organic debris are allowed to exit the system along with the flow of the open water. While there has been much recent interest in cage fish farming, there is, as yet, no means for purifying the debris from the water before the effluent is sluiced into the open water (fig 27).

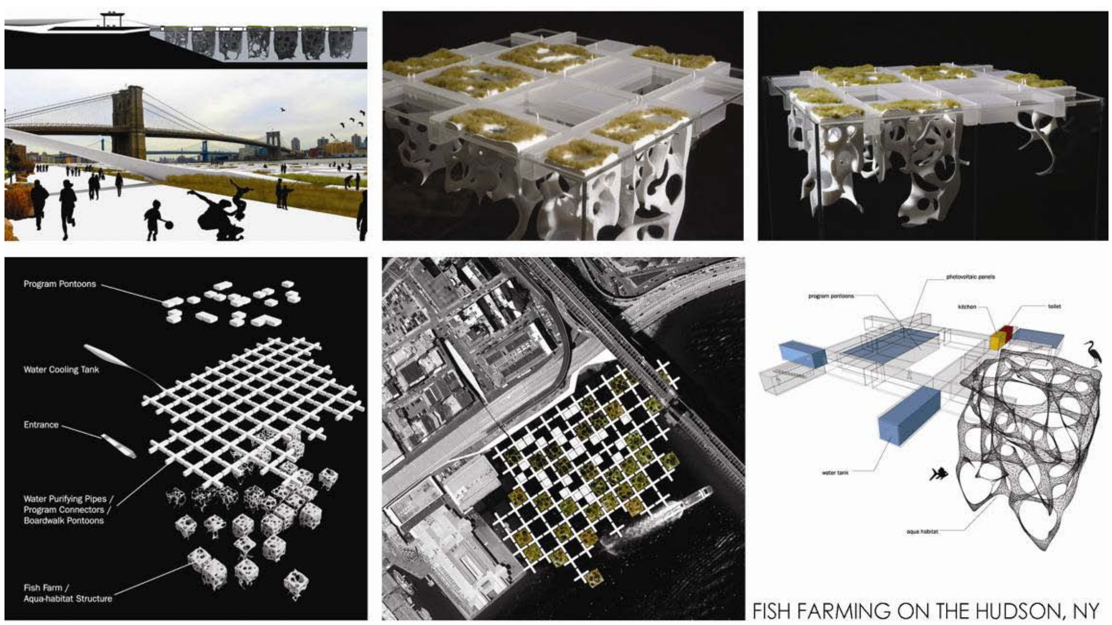
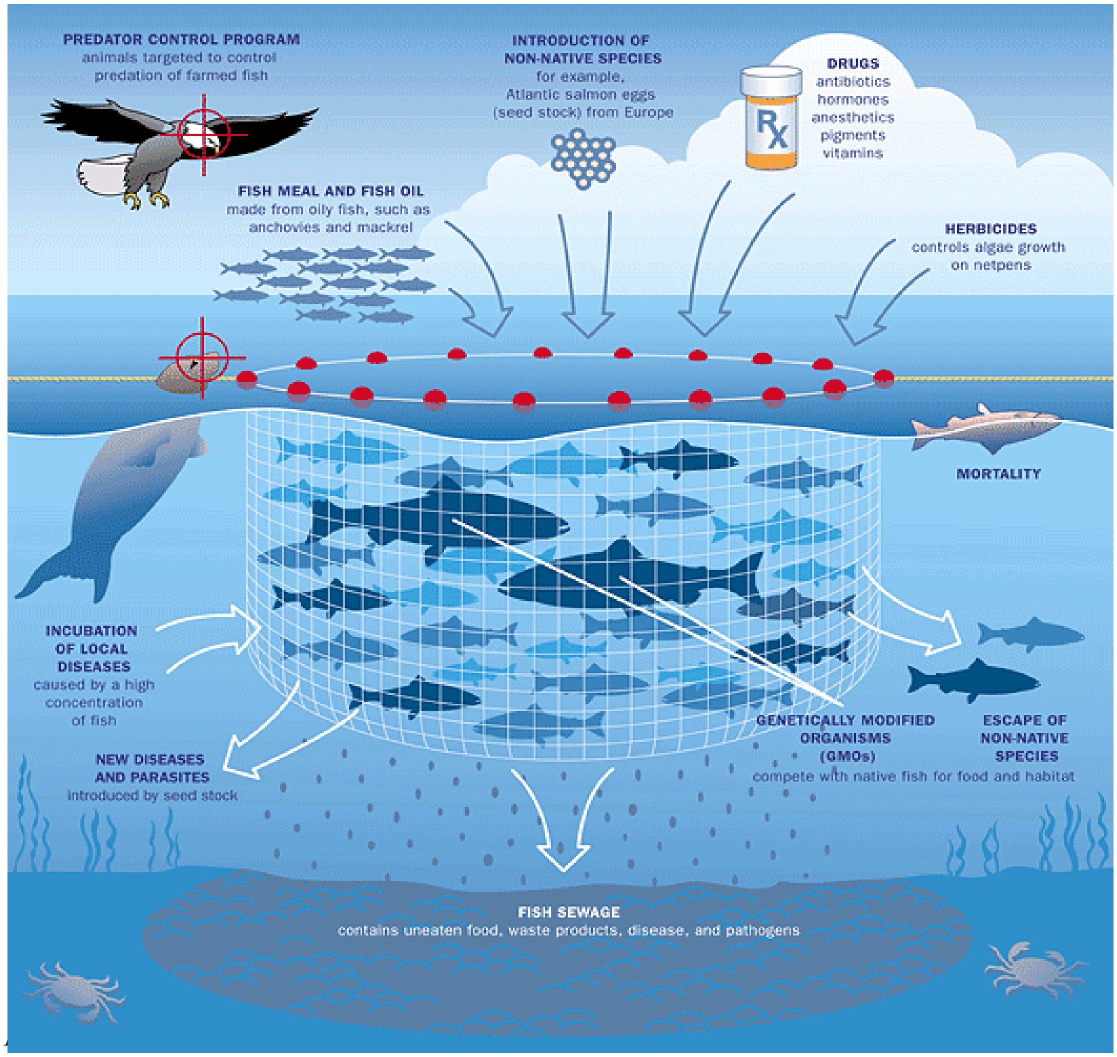


Figure 26 - Winning Entry—South Street Seaport by N.E.E.D. Architects, 2008.



http://www.motherjones.com/environment/2006/03/aquaculture-environmental-impact

INTEGRATED RECYCLING SYSTEMS

Within the aquaculture industry, integrated recycling systems are thought to offer the best way of minimizing the use of natural water resources while at the same time limiting the production of effluent. Integrated recycling systems consist of large plastic, metal, or concrete tanks in greenhouses. The marine livestock are supplied with nutrients and a food source (typically algae); the waste in the system is slowly circulated to hydroponic beds near the tanks, where carefully cultivated microorganisms convert ("fix") the ammonia to nitrates which fertilize the plants along with the phosphates from the tanks. Other wastes are strained out by the hydroponic media, which can double as aerated pebble-bed biofilters (fig. 28).

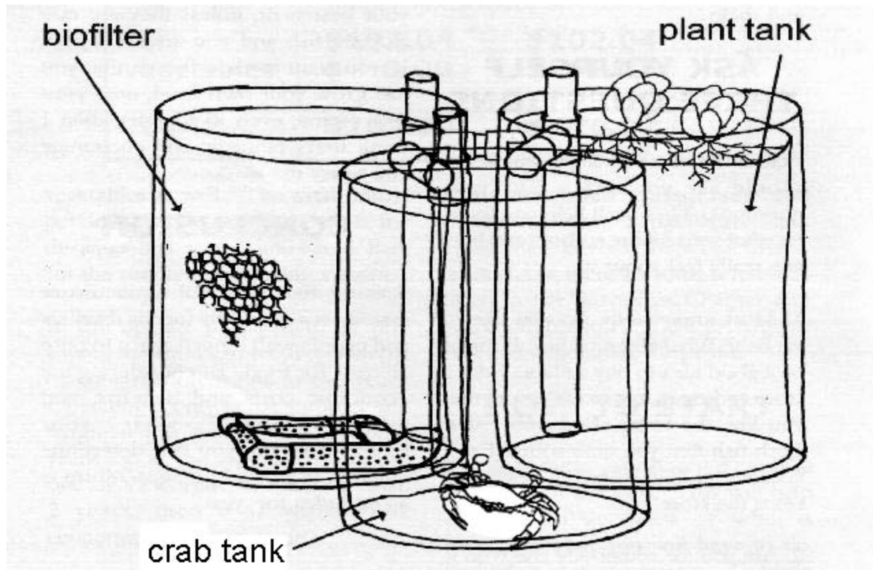


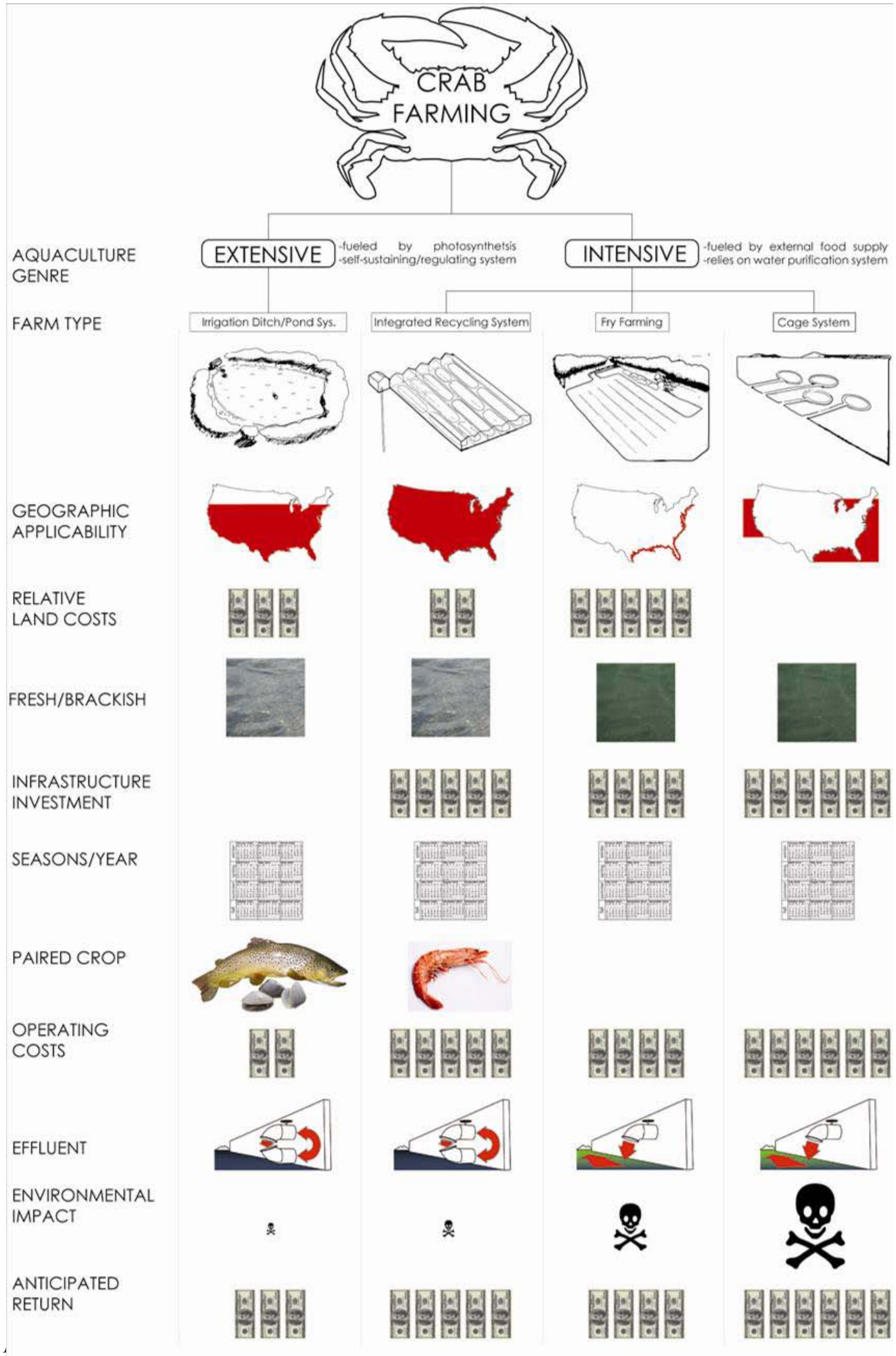
Figure 28 - Hydroponic Recirculation Diagram. Author illustration

This system, properly calibrated, produces more edible protein per unit area than any other form of aquaculture. Although a wide variety of plants can grow well in the hydroponic beds, most farms focus on herb production (e.g. parsley and basil), which command premium prices in small quantities year round. The most common customers are restaurant wholesalers. Since the system is greenhouse based, it adapts to almost all temperate climates, and may also be employed in tropical climates. The main environmental impact is the discharge of salt water. Currently, farmers use a variety of proprietary techniques to treat and reuse water, thereby reducing their expenses for salt and waste water discharge permits. In order to treat effluent and avoid expensive discharge permits, many farms are beginning to rely on ultraviolet and ozone disinfectant systems. These range in cost but are not unaffordable relative to the entire cost of the system.[20]

After performing a cost/benefit ratio analysis on the four types of fish farming (fig. 33), it became abundantly clear that an integrated recycling crab farm would provide the most edible mass with the smallest financial investment. At the same time, this farm would pose the least environmental threat. And while integrated recycling can be performed anywhere and is therefore not site specific, it can be made so by adapting its voluminous intake/outtake water needs to the local topography and regional plant ecosystems. For these reasons, an integrated recirculating crab farm was deemed the most sustainable, practical, and realistic for Maryland's Eastern Shore.

---

[20] *Freshwater Aquaculture: A Handbook for Small Scale Fish Culture in North America*, by William McLarney


CRAB
FARMING
AQUACULTURE GENRE
EXTENSIVE
-fueled by photosynthetsis
-self-sustaining/regulating system
INTENSIVE
-fueled by external food supply
-relies on water purification system
FARM TYPE
Irrigation Ditch/Pond Sys.
Integrated Recycling System
Fry Farming
Cage System
GEOGRAPHIC APPLICABILITY
RELATIVE LAND COSTS
FRESH/BRACKISH
INFRASTRUCTURE INVESTMENT
SEASONS/YEAR
PAIRED CROP
OPERATING COSTS
EFFLUENT
ENVIRONMENTAL IMPACT
ANTICIPATED RETURN

LAB REQUIREMENTS

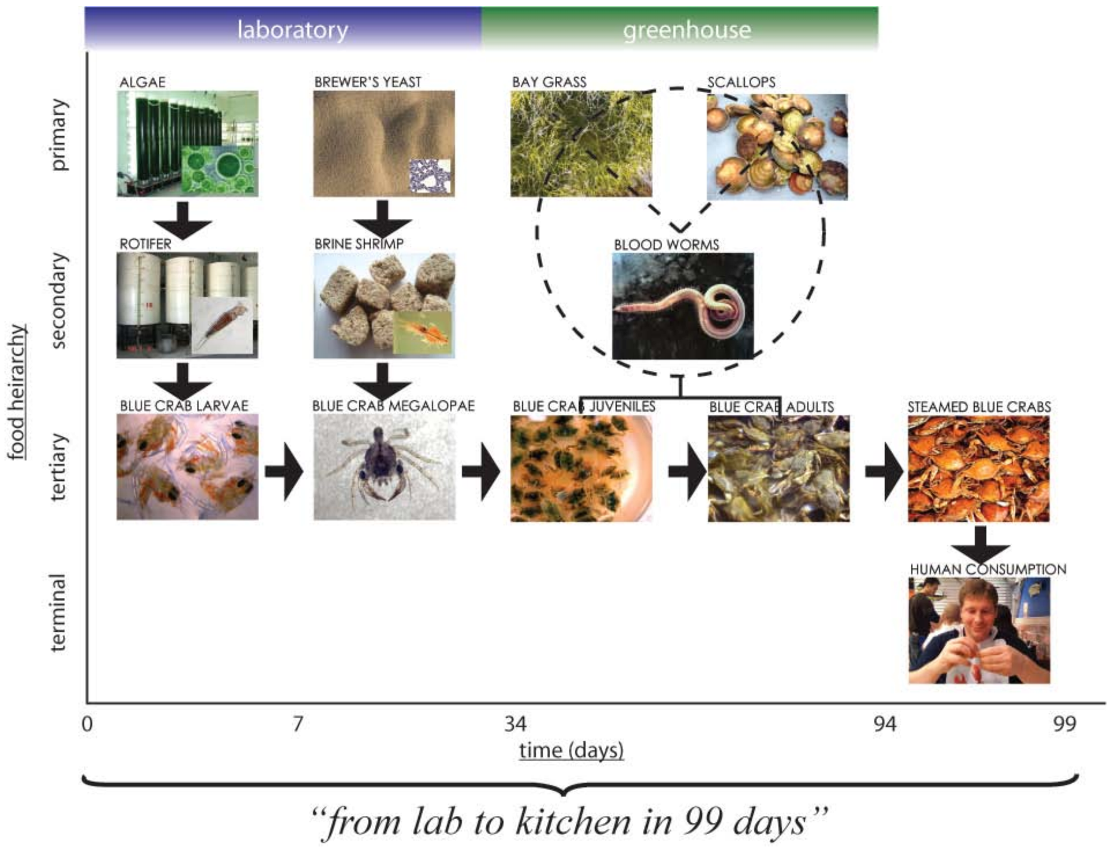


Figure 30 - Food Sources and Growing Timeline. Author Illustration

The laboratory requirements remain the same regardless of which type of aquaculture is pursued. Female crabs must be kept, mated, and their fertilized eggs harvested after brooding. The female crabs are housed in 90G fiberglass tanks with a footprint of about 1' x 2'. These tanks can be stacked onto shelving in order to minimize space requirements. The females are partnered with males for mating on a 4 foot by 8 foot table subdivided into 1 foot by 1 foot by 1 foot slots. After insemination and brooding the lab technicians harvest the fertilized eggs on a large workbench with several large sinks, flexible lighting, and materials storage. Immediately adjacent to this workspace, there will be a walk-in cooler/freezer and access to large quantities of sterile fresh/salt water. The most important aspect of the lab design is the drainage, because an improperly designed drainage system will require hours of cleanup where a better-designed one might only require minutes. Some successful operations use floors sloped into 1' wide and deep canals that run to a main drain.

When the eggs hatch and the blue crabs emerge as larvae, they quickly begin to develop through the 7 larval stages. As larvae, the blue crab is fed with rotifers, a phylum of microscopic and near microscopic pseudocoelomate animals. These rotifers can be raised in centrifuges or large tanks, and they are fed in turn using algae. If the rotifers are raised in centrifuges, the algae can be concentrated into paste and supplied in this manner. Otherwise, the algae would be grown in acrylic bags/cylinders, a process requiring a half-time employee. The crab larvae themselves are raised in 500 fiberglass tubes.[21] They are somewhat expensive but, when empty, they are very light and can be easily shuffled around by a single person. Each tube holds approximately 10,000 liters and are stocked with larvae to a density of 150/L each. Four such tubes per raceway would be sufficient for a farm project of this size.

When the blue crab develops into the post-larval, or megalopae stage, it requires a food source of a higher biological order. Artemia, also known as brine shrimp or more commonly as sea monkeys, are a low developmental order crustacean perfect for this second round of live feed. Artemia feed on algae, brewers yeast, or even egg yolk. The artemia are hatched, grown, and concentrated in a series of 200L conical buckets. These buckets have a radius of approximately 2'0" and it is believed that 6 to 8 would be needed for this operation.

When the blue crab develops from the megalopae phase and into the juvenile state, he undergoes some substantial changes. From this moment forward, the crab is capable of withstanding waters with saline content as low as 3ppt, and his food sources become substantially more complex. Blue crabs can eat almost anything, but they prefer to eat worms, oysters, scallops, bay grasses, small fish and of course other crabs. Because the crab will grow in size so very substantially during this phase of his life, there is no room to house him in the laboratory. From this point, the blue crab enters the second phase of his geographic life—the raceway phase.

RACEWAY REQUIREMENTS

Scientists at the University of Maryland's Center for Marine Biotechnology believe the maximum density in which adult blue crabs can survive is somewhere in the neighborhood of 6-9 crabs per cubic yard, or 300 crabs per hectare. According to COMB's Odi Zmora, the ideal depth for these ponds or raceways is somewhere around 1 yard.[22] As blue crabs are a

[21] For a visual, go to Solar Components Online—www.solar-components.com.
[22] Interview with and Odi Zmora, COMB Master Nutritionist, conducted 02.12.09.

molting species, there is no need for antibiotics, and disease is rare. Given that the raceway system recirculates water through an inline filtration system, the ponds will not need to be emptied more often than once at the end of every growth cycle (4 times/yr). This will ensure that all adult crabs are removed from the system and that the water is fully remediated in the wetland before it is pumped back into the raceway for reuse with a new crop of crabs. If an adult crab were to remain in the system, he would systematically eat all smaller crabs over the course of the next growth cycle. As crabs are a cannibalistic species, the amount of defensible space is proportional to the rates of survival. Given the proper raceway landscaping, it is thought that ponds/raceways could produce survival rates of somewhere in the neighborhood of 20% - 50% (fig. 31).[23]

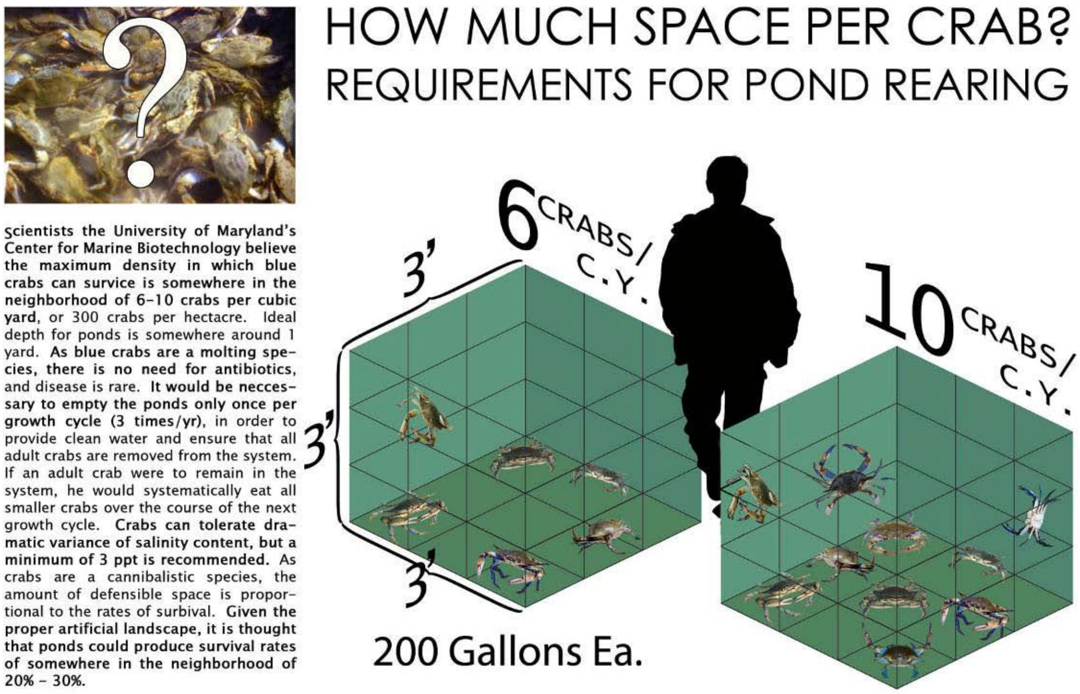


Figure 31 – Spatial Requirements. Author illustration.

One of the biggest challenges for the enclosed raceway system is the issue of rainwater. Since the concentration of salts and other trace elements are actively monitored and maintained, the irregular introduction of rainwater into the raceway system could dramatically affect a precarious electrolytic balance. Thus, it is believed that rainwater should be entirely diverted from the raceway system. This requirement determined the need for onsite water detention and retention ponds, and in many ways shaped the final outcome of the landscape strategies.

[23] Interview with Dr. Yonathan Zohar, COMB Director, and Odi Zmora, COMB Master Nutritionist, conducted 02.12.09

PROGRAM AND PROCESS

Given the requirements outlined above, the blue crab farm functions as a microcosm of the Bay—one that replicates the nature and character of the blue crab's entire lifecycle. The crab is conceived, gestated, and birthed in the lab. It is there that each crab grows through the two phases of larval/post larval development, and is subsequently sluiced via pipette to the loading dock to begin its new life in landscaped raceways. The blue crab will spend the next 90 days of his life in a 42 foot wide by 240 foot long concrete pond filled with submerged aquatic vegetation (SAV) and infauna (worms, mollusks, etc.) in order to approximate the blue crab's natural environment. In each raceway, there is a continuous purification system that exposes water to UV light and provides a very slight current to keep water fresh throughout. Given the proper food, at the end of the 90 days, it is believed that the surviving crabs will have grown to full size, and will be ready for harvesting.

When the crabs are ready for harvest, the raceway water will be sluiced directly from the raceway into the adjacent wetlands, where the natural grasses will begin the process of breaking down the trace nitrates and phosphates that have not been treated by the inline UV filtration system. When the raceway has been emptied, the crabs will be removed from the raceway by hand and wheelbarrow, and placed in dump trucks for transport back to the picking/processing facility. Once the crabs have reached the facility, they will be dumped into a stainless steel chute and sorted by the steam staff. Some crabs will be substantially bigger than others, and these will be pulled to the side for sale as jumbo live crabs. The rest will be steamed and refrigerated before being picked. After refrigeration (which causes the meat to contract in the shell therefore making the crabmeat easier to pick) the crabs arms and legs will be removed using a mechanical chopper, and the body, or carapace, will be chopped in half, also using a machine. The body is then distributed to the hand-pickers who extract the meat at a rate between twenty and sixty crabs per hour. At the end of the shift, each picker will carry their bucket of crabmeat to the weigh-table for weigh-in and inspection. The debris and detritus from the picking operation will go on to secondary picking, in which the remaining crabmeat and guts is strained from the chitinous exoskeleton and processed. No part of the crab, save the exoskeleton, is wasted. Even the guts will be sold to local restaurants that will use this byproduct to flavor less tasty imported crab meat. Once the crabmeat is weighed, it will be packaged in plastic containers, boxed, and refrigerated, ready to ship.

The facility portion of the program breaks down into three parts—laboratory, picking/processing, and public. As such, the best diagram for the facility is a three-way Venn diagram. Each part overlaps at shared programmatic elements, like the loading dock, the lobby, etc. Because the working program is conceived of as an aquarium of sorts into which the public can look, the public functions naturally take on an interstitial or corridor-like nature. From this gallery, the working operations of the program are made clearly evident to the visitor, almost like a tour of an assembly line. It is believed that this show-like environment will generate a substantial secondary income from tours.

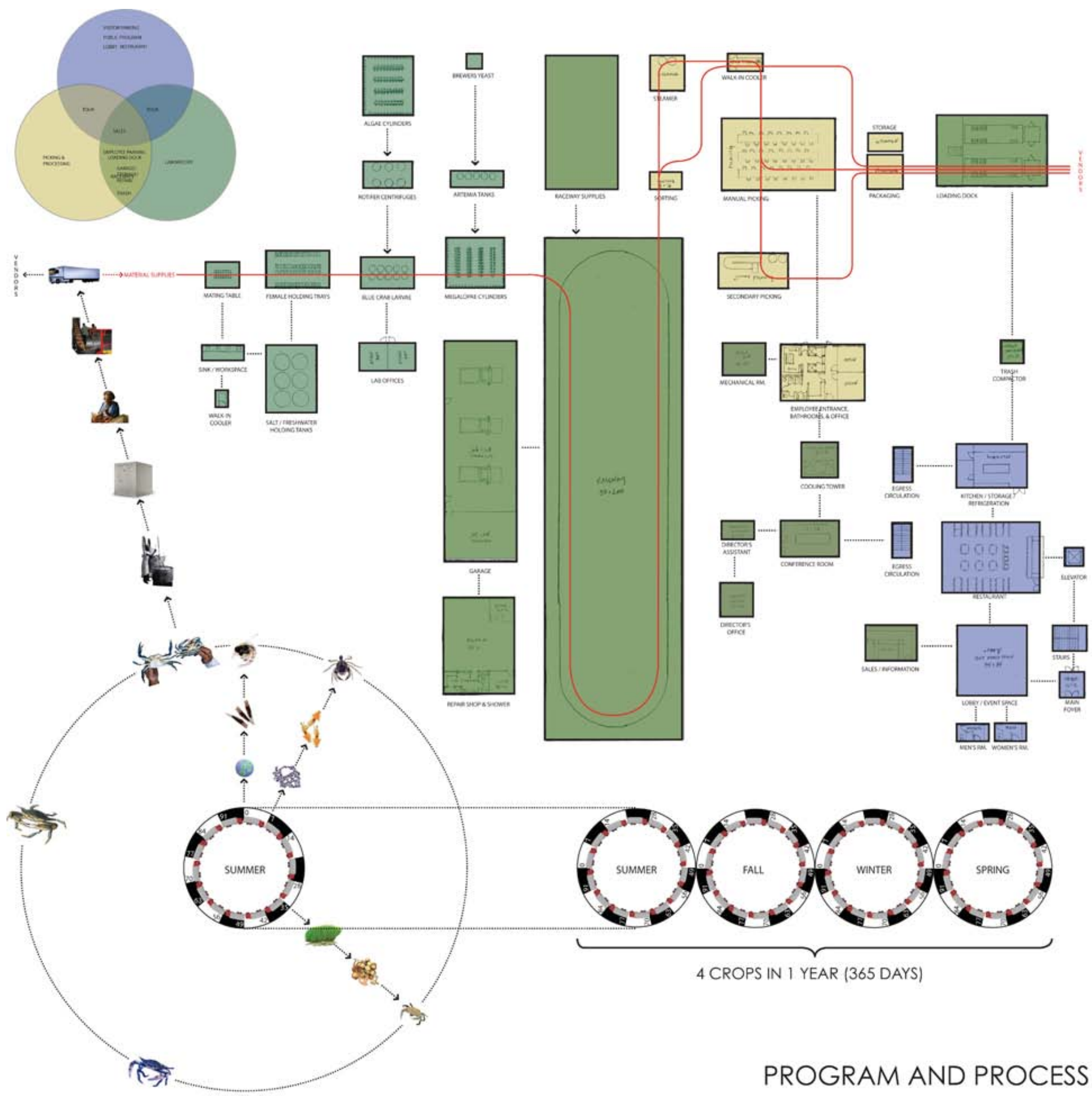


Figure 32 – Program and Process Diagram Relating Timeline to Physical Movement of the Crab through the System. Author Illustration.

REGIONAL HISTORY

Maryland's history is indebted to and intertwined with the history of the blue crab. Some scholars believe the blue crab dates back to the Eocene or the Oligocene era, but the earliest uncontested specimens come from the Miocene horizon (figure 33).[24]

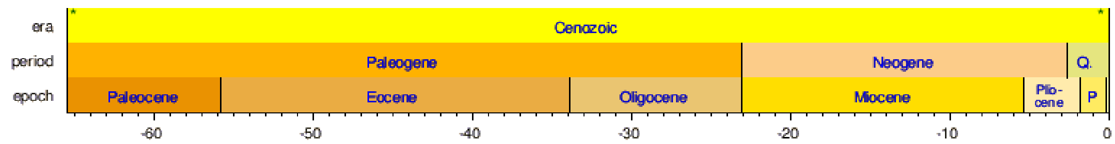


Figure 33 - Cenozoic (Current) Era. Bottom Slider in Millions of Years. Image Courtesy of Wikipedia - http://en.wikipedia.org/wiki/Geologic_time_scale

Blue crabs have been have been fished and caught by man since before the dawn of recorded history. The earliest reference to blue crab as a foodstuff in our region occurs in Western History when Hamor (1615) narrates that the Indian Chief Powhatan served visiting Europeans crab as part of a breakfast meal.[25] During the 1700s the blue crab was commonly eaten along the Midatlantic but not far from where it was caught. Salting and drying methods of preservation do not lend themselves well to crabmeat, and thus the blue crab was not transported out of the Midatlantic until the birth of ice-cooling. Crabmeat will stay fresh on ice for a period of only 10 days, so there are also limitations on how far afield it could be transported until recent developments in flash freezing and refrigerated trucking.[26]

Much of the science behind crabbing technology was developed here in Maryland. Crabbing in Maryland began as a netting activity. But over time, the technology evolved from one of hand held nets and baskets and into wire mesh traps that could be left in the Bay over a period of days and nights—then subsequently emptied when the waterman returned to empty its contents (figure 34).

---

[24] Kennedy & Cronin—The Blue Crab: Callinectes sapidus, page 15
[25] Kennedy & Cronin—The Blue Crab: Callinectes sapidus, page 656
[26] Kennedy & Cronin—The Blue Crab: Callinectes sapidus, page 657

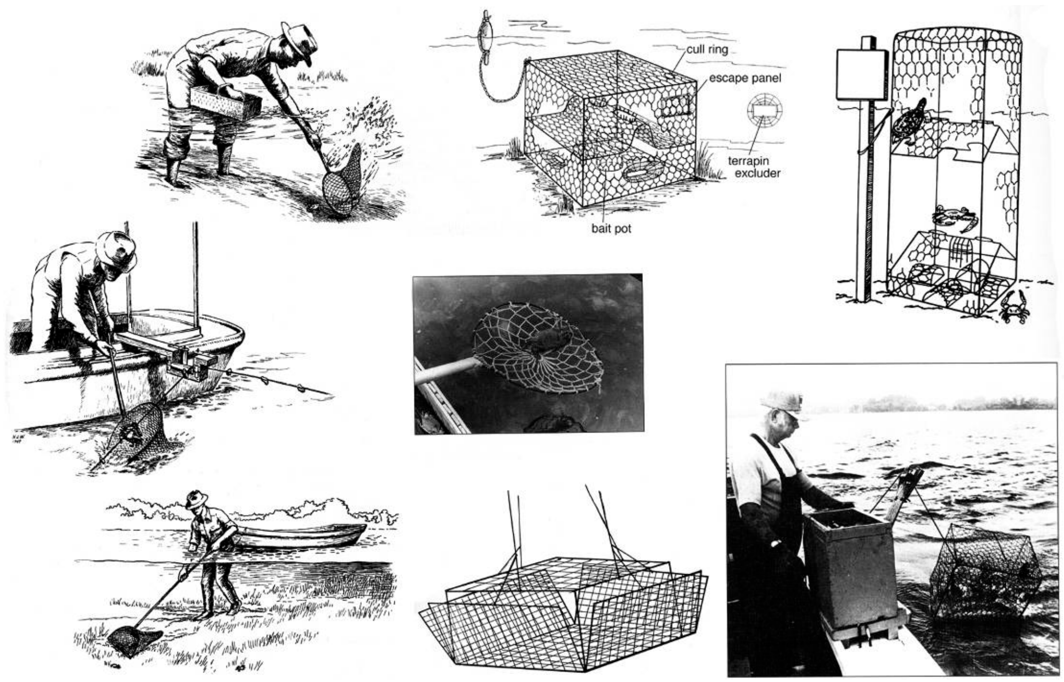


Figure 34- Crabbing using nets, baskets, and traps. Images courtesy of Kennedy & Cronin.

Over time, the scope and nature of the crabbing apparati evolved. Nets and baskets evolved into dikes and stream diverters (fig. 35). These inventions were ultimately not as effective as the traditional crab pots—the technology preferred by watermen up to the preset day.

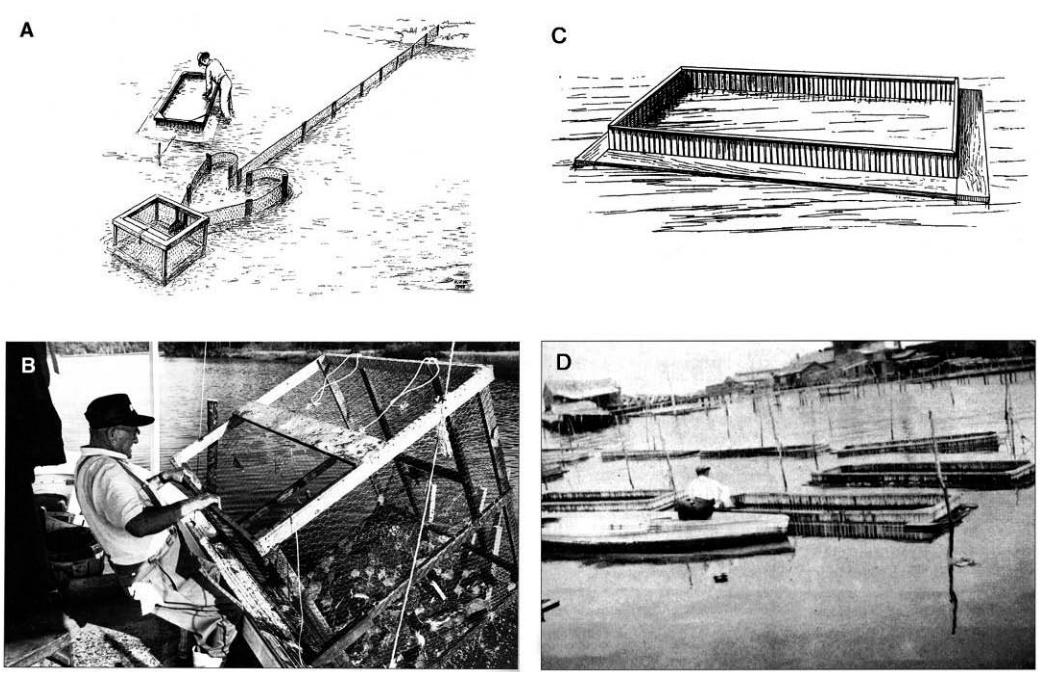


Figure 35 – Crabbing in Maryland using catch-basin traps. Images courtesy of Kennedy & Cronin.

Historically, the Maryland crabbing industry has revolved around adult males or jimmies. After a day's work, watermen would sell their live catch to local picking/processing facilities, crab shacks, and restaurants. The industry operated in this manner for over a hundred years. But things are changing. There are not enough crabs and oysters in the Bay to provide watermen with a reasonable livelihood. And what is more, it seems that market tastes are changing also. Jack Brooks of JM Clayton suspects that the Maryland blue crab industry is transitioning from hard-shell jimmies to soft-shell crabs, or "peelers".[27] These suspicions are confirmed by several local experts.[28] Not only is the soft-shell crab something of a delicacy in traditional mid-Atlantic cooking, there is a large market for soft-shell crabs in many Asian recipes. Along the Maryland coast, there are a few independent farming operations that raise soft-shell crabs in stacked PVC trays supplied with a continuous flow of moving water. These cells are monitored at regular intervals, and once the crab has vacated its exoskeleton, the farmer will remove the crab and put it on ice, thereby inhibiting its ability to regrow its shell. The peeler will then be sent directly to market for sale. According to Ernest Williams of the University of Maryland Biotechnology Institute, a contemporary blue crab farming operation will make its maintenance/operations payments on sales from hard-shells but will make its profits on sales from these peelers.[29]

As mentioned previously, Dorchester County is the historic home of the crabbing industry in Maryland. As a primarily rural community of 30,000, Dorchester's historic industries include farming, oystering, crabbing, and timbering. Of these four principal industries, only two remain viable to this day—farming and crabbing, and the crabbing industry is starting to atrophy. English colonists began to populate the area in the 1700's, when it was discovered that Dorchester's farmland was incredibly fertile. This was the result of vast sedimentation from centuries of streams running out into the Chesapeake Bay. Dorchester County was the site of the last remaining Indian reservation in Maryland and, based upon its particular landscape geography, boasts the greatest wildlife preserves in the region.[30] The southwestern portion of the county is comprised of a series of islands that protect a series of low-lying wetlands, home to some of the Nation's most notable wetlands preserves including the Blackwater National Wildlife Refuge.

[27] Author's interview of Jack Brooks, managing director of The JM Clayton Co, conducted July 2, 2009.
[28] Ernest Williams Interview 02.12.09.
[29] Ernest Williams Interview 02.12.09.
[30] http://www.preserveamerica.gov/firstPAcommunities-dorchestercountyMD.html

The Terraced landscape of Dorchester County prevents uphill migration of Bay waters and simultaneously ensures that the low lying southeastern portion of the county retains water four seasons a year. The County steps up to the west in a series of two-to-four-foot terraces (fig. 36). As a result, the southern portion of the county is home to some of the most fecund wetlands in America. But rising waters associated with climate change pose an imminent threat to these low lying areas, and it is believed that as much as half of Dorchester county will be lost due to climate change over the course of the next 50 years.

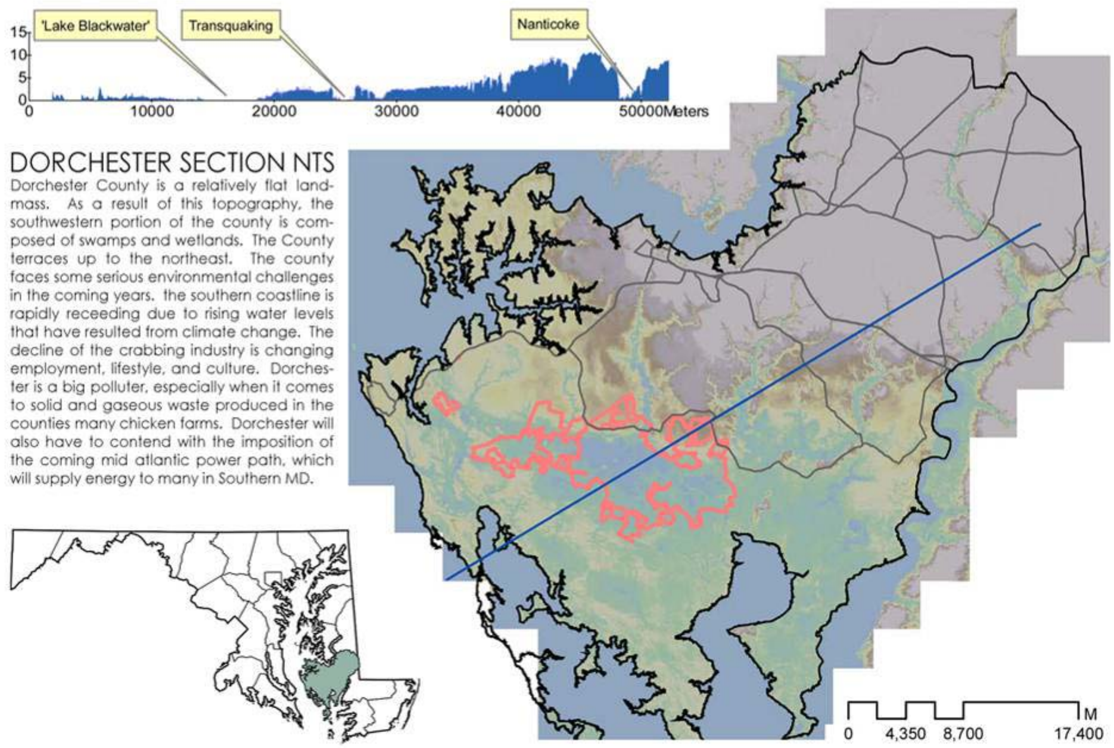


Figure 36 - Section Through Dorchester County (Y-Axis Exaggerated for Clarity). Author illustration with image courtesy FWS - http://www.fws.gov/blackwater/restoration/Kopecky_blackwater_0507.pdf

As historic home to the crabbing industry in Maryland, Dorchester boasts more picking and processing facilities than any other county in Maryland. However, the drastic decline in blue crab harvests over the past ten years has put many of Maryland's historic family-owned picking-processing facilities out of business. According to Jack Brooks of JM Clayton Co Seafood, there were more than 50 picking and processing facilities on the Eastern Shore in 1985. Today, there are approximately 15 still in operation. The collapse of the picking and processing industry in North Carolina and Georgia means that these few picking facilities represent an overwhelming majority of domestic lump and backfin crabmeat production.

New York and North Carolina have viable commercial crabbing industries, but they tend to concentrate on live product. While the Mid-Atlantic market has historically been dominated by the sale of large male specimens, the New York market in particular focuses on smaller, pregnant female crabs whose eggs flavor several Asian delicacies.

In 1995, most of JM Clayton's product went to large supermarkets such as Giant and Safeway. Now, the big grocery chains import all their crab from abroad, and the Maryland Blue Crab, something of a delicacy, is sold directly to restaurants and specialty markets. The bulk of JM Clayton's product is destined for Charleston, Myrtle Beach, Annapolis, the Delaware resort beaches, Washington, Baltimore, southeast Pennsylvania, and other high-value markets that range as far north as Boston. Whole Foods Market is the only supermarket JM Clayton still sells to.

Looking to JM Clayton as a model for selling and distributing blue crabmeat to a expanding boutique market, one could begin to imagine the Whole Foods distribution network as a template for how farmed crabmeat could be distributed in the Midatlantic, Northeast, and Southern regions (fig.37). Dorchester (or perhaps Wicomico County) would be the perfect seat from which to stage such an operation because of regional highway access, and its position at the center of four thriving markets. With this thought in mind, the thesis looks to develop and design a working crab farm located in Dorchester County, Maryland.

Figure 37 - Extended Distribution Network. Author's Speculative Illustration.

SITE ANALYSIS

The proposed site is located at the very eastern edge of Dorchester County, where the Nanticoke River divides Dorchester from Wicomico County (fig. 38). Route 50, "Ocean Gateway Highway," forms the southern boundary of the site. As 50 serves as one of the main arterial roads leading to and from the Maryland/Delaware resort beaches, it is believed that a strong street presence would generate a singnificant number of drive-by visits. This site was particularly selected based upon the fact that most of southern Dorchester County is marshland, and there is a limit to how far south/southeast in the county a crab farm operation of this type could effectively work. Directly east of the site is the Vienna Electric Power Station and cooling water reservoir, which provides power to much of the Eastern Shore of Maryland and Delaware. The site is almost immediately adjacent to the Nanticoke River, a low-lying and mostly tidal river, but the facility does not take water in from the river, nor does it sluice water back. This eliminates the need for expensive water rights permitting. According to the Nanticoke Watershed Alliance, the river is one of the healthiest on the Easter Shore and its 370-000-acre watershed is host to a wide range of animal and plant life, including the greatest concentration of Bald Eagles in the northeast.[31] The historic town of Vienna, Maryland lies directly southwest of the proposed site, and would hopefully house a great number of the employees that work the picking facility. According to Vienna town planners, prevailing winds are from the northwest during the winters, and the southeast during the summer.[32] This statement is verified by wind-rose information from the town of Bishop's Head, Maryland, and will play a defining role in the east west orientation of the complex.

[31] Information provided by The Naticoke River Alliance. http://www.nanticokeriver.org/
[32] Telephone interview with Mary Jane Marie of the of the Vienna Planning Department, 09.28.09

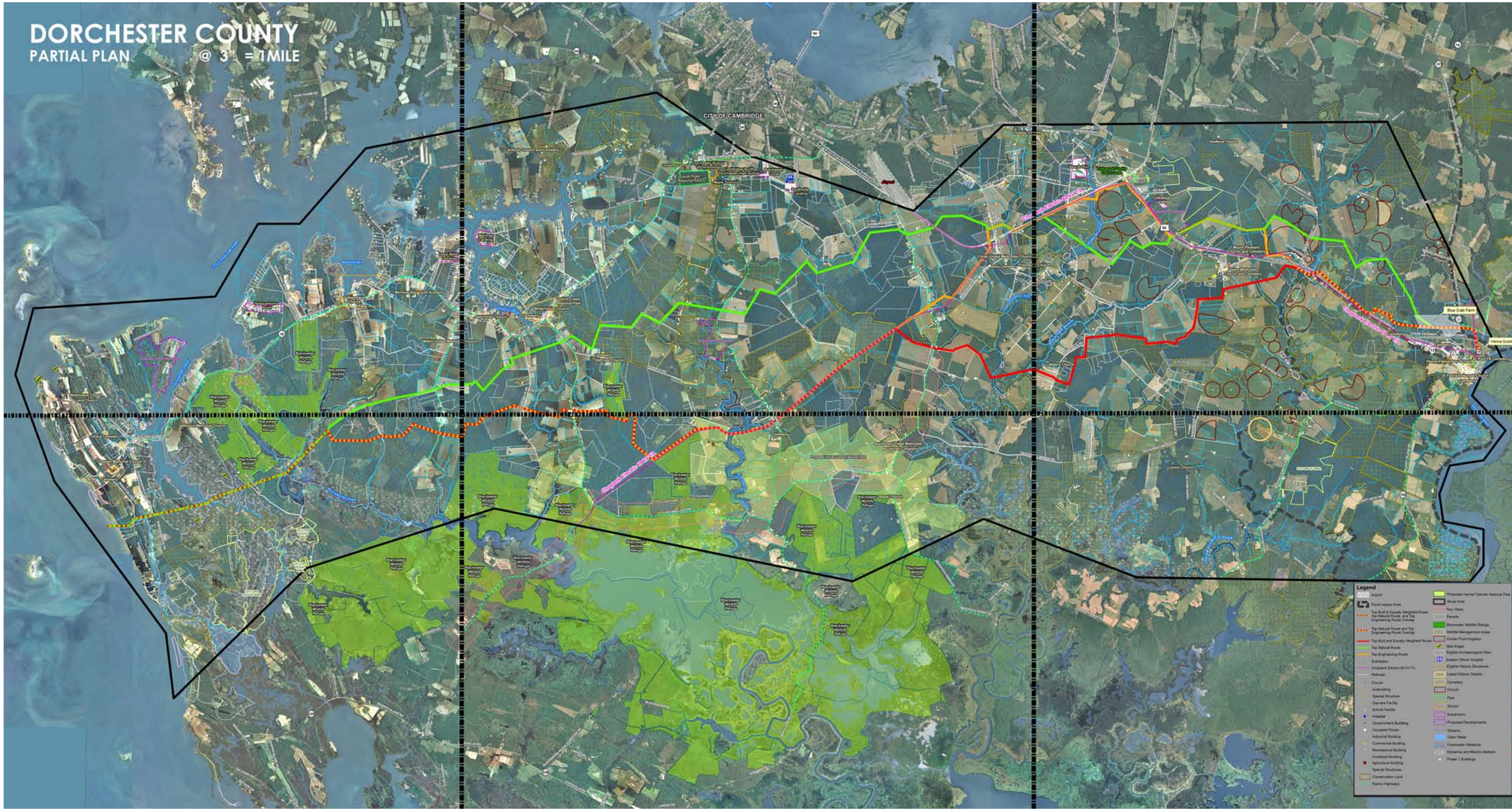


Figure 38 - Dorchester County Partial Plan with Land Uses and Proposed Power Pathway Routes. Author illustration; base image courtesy Pepco Holdings, Inc.

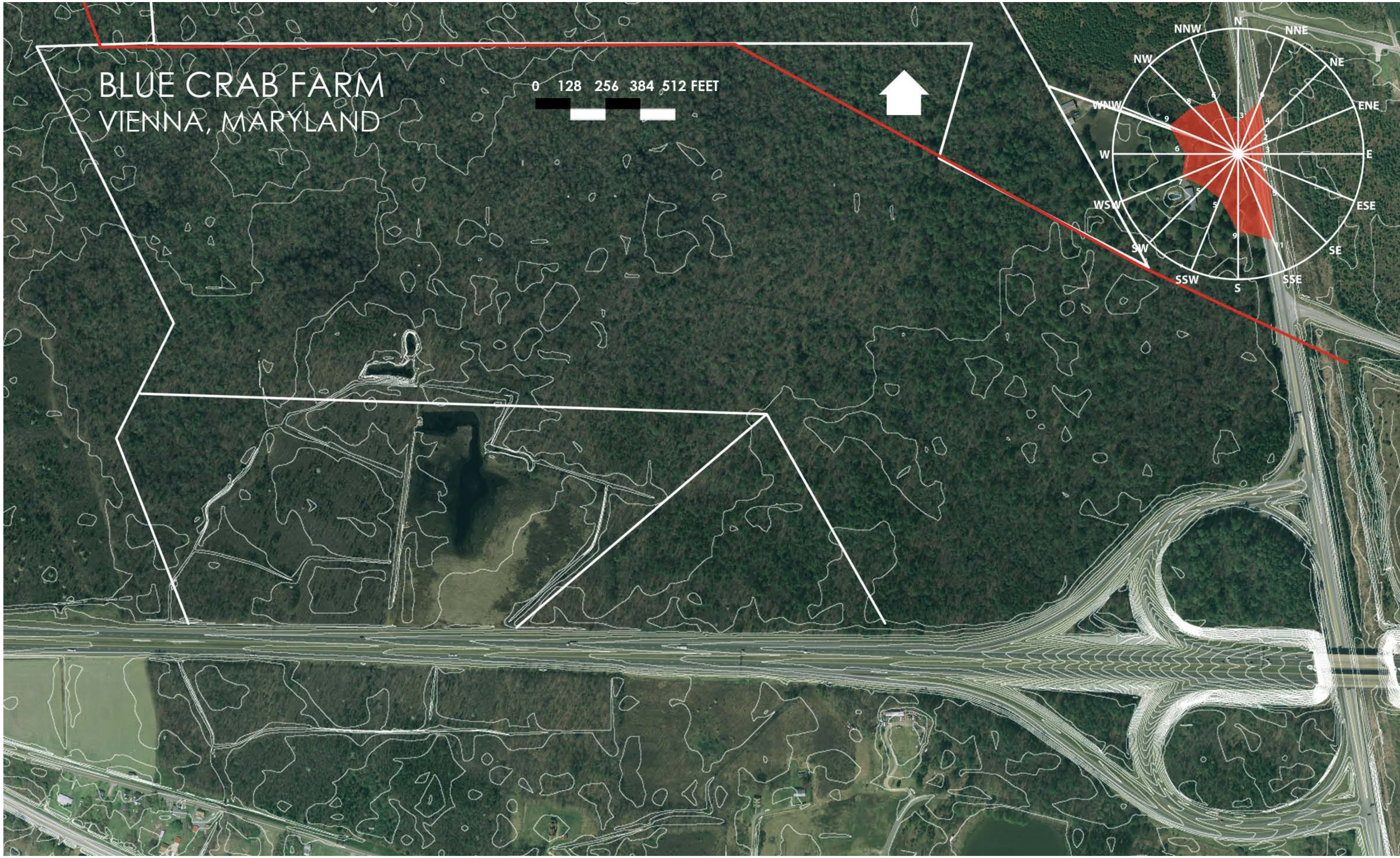


Figure 39 - Proposed site showing property lines in white, 1 foot topography in light white, and the proposed MidAtlantic Power Pathway routing in red. Wind rose information is in the upper right corner. Route 50 runs east-west along the southern border of the site. Author Illustration.

PRECEDENT ANALYSIS

The J.M. Clayton Co. complex is situated on a small promontory ½ mile to the east of the Cambridge, MD draw bridge (figure 40). The facility is an ad-hoc agglomeration of buildings organized around a central courtyard (fig. 41). As such, it acts as a two-sided work complex. Crabbing vessels are received at the south and the east, and truck access is from the northwest. This layout affords the facility access to boats around the periphery and allows cars and trucks to penetrate the heart of the facility. According to Brooks, this was not a planned development, merely an accretive agglomeration of a oyster shack to the north and a crab picking shack to the south. According to Brooks: "Every year the Maryland department of health comes out here to look at our operation. Every year they complain because after steaming and refrigeration, the crab has to come out-of-doors to make its way to the picking house. We just tell them that we've been doing it this way for over a hundred years, and they let it go."[33] In an ideal world, however, Brooks admits that once the crab is cooked and refrigerated, it should remain indoors as it makes its way to the hand picking, machine picking, and packaging operations. When asked to envision his ideal picking and processing facility, Brooks concedes that the building would probably look like one big warehouse large enough to allow for trucks to enter into the building and park in conditioned space. He reiterates this would be particularly important if the facility was to operate year-round.

---

[33] Author's interview with Jack Brooks, managing director or The JM Clayton Co, conducted July 2, 2009.

Figure 40 – JM Clayton Co. picking processing facility, Cambridge, Maryland. Author photo.

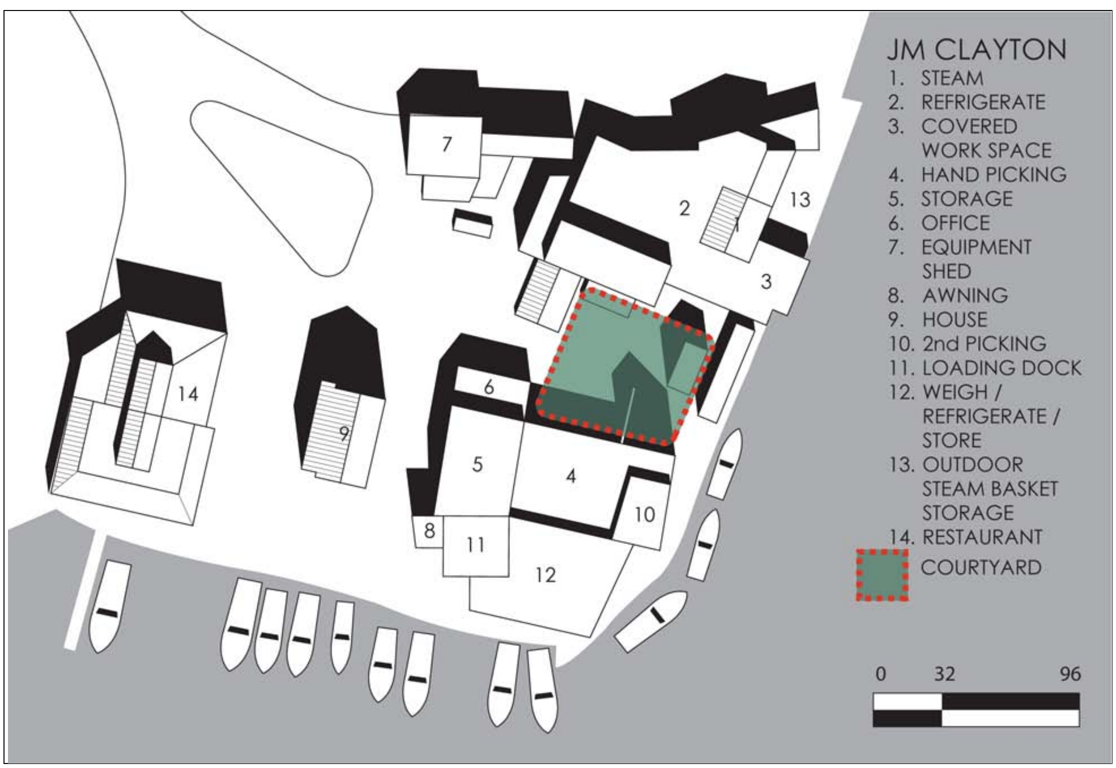


Figure 41 - JM Clayton Co Site plan with Working Courtyard Highlighted. Author Illustration.

DESIGN PROCESS

Although crab is a benthic, and thus bottom feeding, species, the blue crab adult are somewhat inefficient eaters and tend to leave behind food remains that are too small for them to consume. For this reason, it was suggested early in the process that the project pair blue crab raceways with shrimp raceways, circulating water between the two such that the shrimp consume the remains of the food left by the crabs. This association was a stepping off point. Along with the requirement for a fallow raceway for water discharge/recharge, this pairing began to inform the size/scale of the raceway component of the project.

Since recirculating aquaculture can be performed almost anywhere and at almost any scale, the first site parti was to imagine the largest, most generic production facility—one that would ignore both the particulars of the site and the requirements imposed by the proposed location in Dorchester County, MD. This site scheme was largely an adaptation of the Thanet Earth compound in the UK (fig. 42) which houses over 1.3 million hydroponic plants in 220 acres of glass enclosed greenhouse.[34]

Figure 42 - Thanet Earth compound. Author illustration. Photos courtesy Thanet Earth

[34] http://www.guardian.co.uk/environment/2008/jun/11/greenbuilding.food

The problems with this first scheme are numerous and readily apparent. A glass enclosed complex of this magnitude would have difficulty venting stale air and moderating temperature. What is more, the vast footprint of the glassed in area will not allow for easy rainwater collection outside the building enclosure (fig. 43).

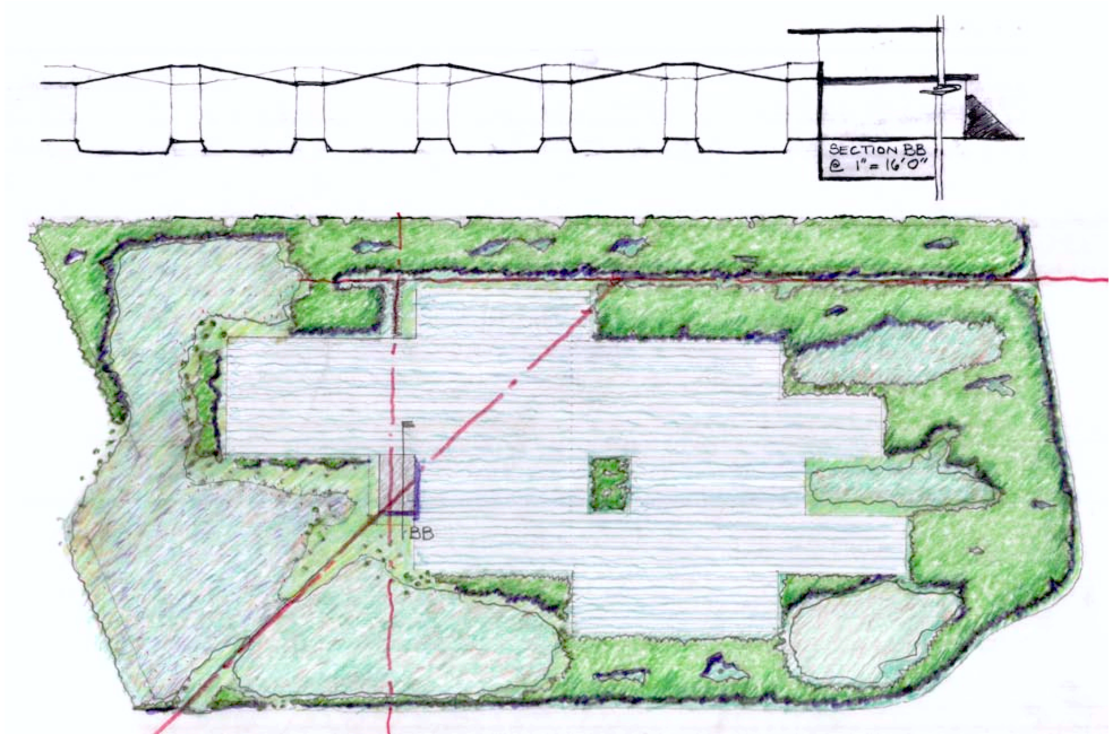


Figure 43 - Site Scheme 1. Author Illustration.

The second site scheme made an attempt to break down the scale of the system, while keeping the pairing of crabs/shrimp intact (fig. 44). This scheme included a central stormwater retention/wastewater remediation feature, but the immense cut/fill required to maintain positive drainage to a central cistern quickly rendered this approach impractical. As a result of this second scheme, the third design focused on breaking down the scale of the greenhouse even further, and localizing rainwater retention/detention features.

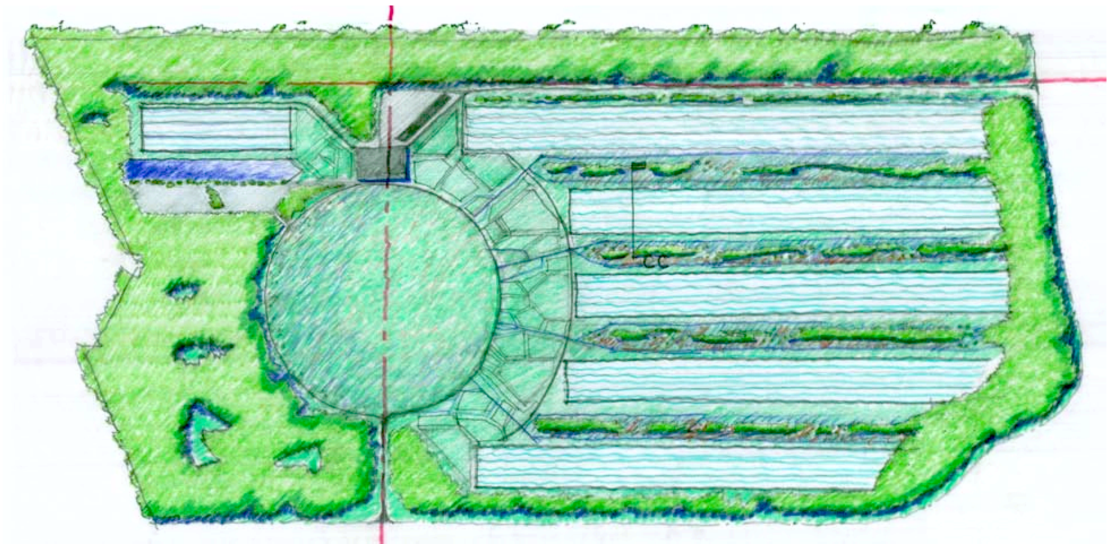


Figure 44 – Site Scheme 2. Author illustration.

Site Scheme 3 revealed the promise of remediating fecal waters in localized wetlands, but, as before, its size was predicated upon the crab/shrimp pairing that conjoined two crab raceways with a shrimp raceway, thus tripling the necessary width of the enclosed space and necessitating a more complicated greenhouse solution (fig. 45).

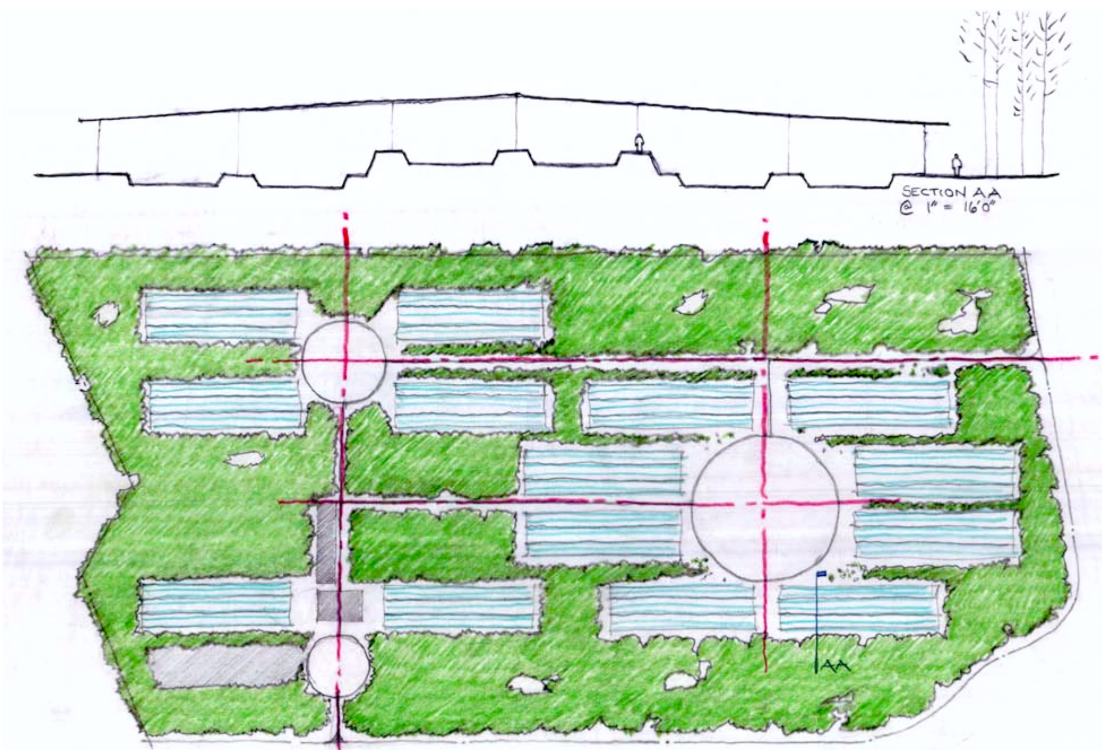


Figure 45 – Site Scheme 3. Author Illustration.

After further research, it became clear that the financial value of the particulate food matter the crab cannot ingest was of small value compared to the costs of the other inputs in the system. Thus, in Site Scheme 4 the crab/shrimp association was eliminated (fig. 46). This scheme attempted to determine the smallest size/scope of a facility that would employ 30 fulltime pickers year-round. This fourth scheme in many ways epitomizes the traditional thinking behind agricultural farming. In this scheme the farm is a single-harvest monoculture carved out of the surrounding ecosystem. As such, there is immense biodiversity at the farm's periphery, but none at its core. The flora and fauna that once populated this site are exiled to the forest's edge, and the farm itself becomes an island of homogeneity in a sea of biodiversity. After reflecting upon this scheme closely, it became clear that herein lay the real dynamic of the thesis: transplanting a species into an entirely artificial ecosystem without changing the very nature of its existence and without seriously impairing the existence of those species displaced by this transplantation.

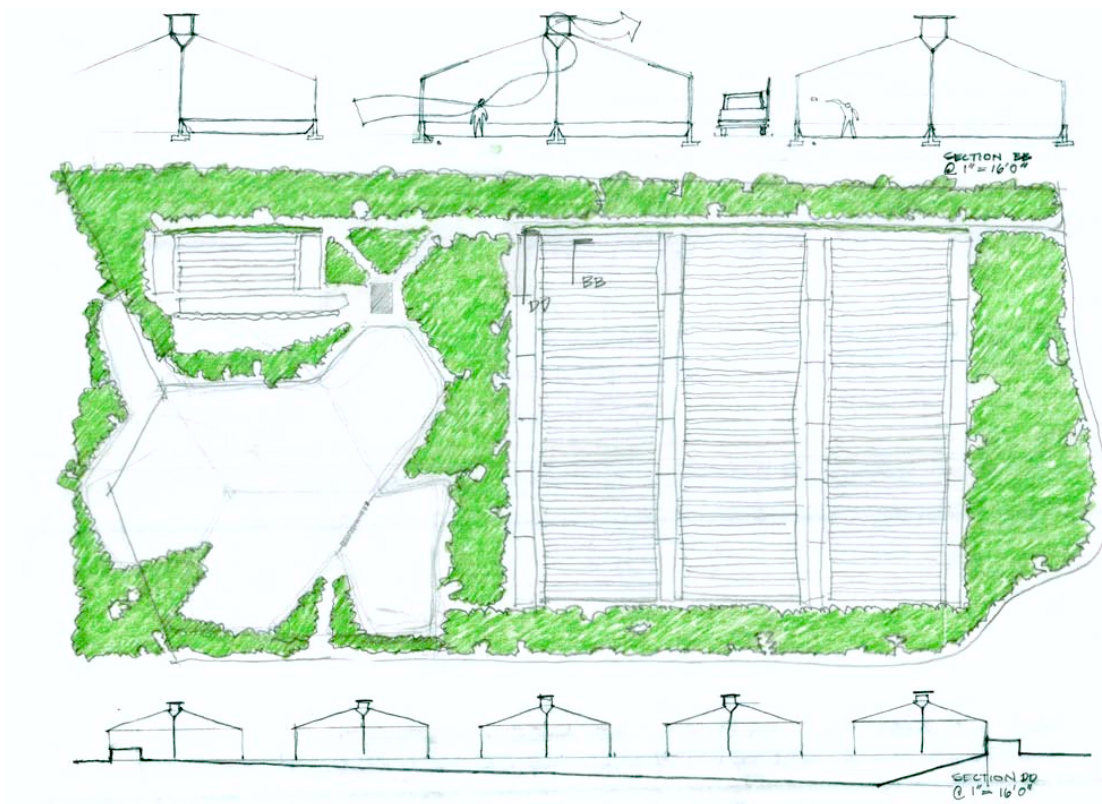


Figure 46 - Site Scheme 4. Author illustration.

Site scheme 5 was a major leap forward (fig. 47). This scheme attempted to disaggregate the crab raceways such that the loblolly pine forest penetrated the site as a series of greenways that could allow animal movement along the periphery of smaller more amorphous clusters of raceways associated with local constructed wetlands for stormwater retention and wastewater remediation.

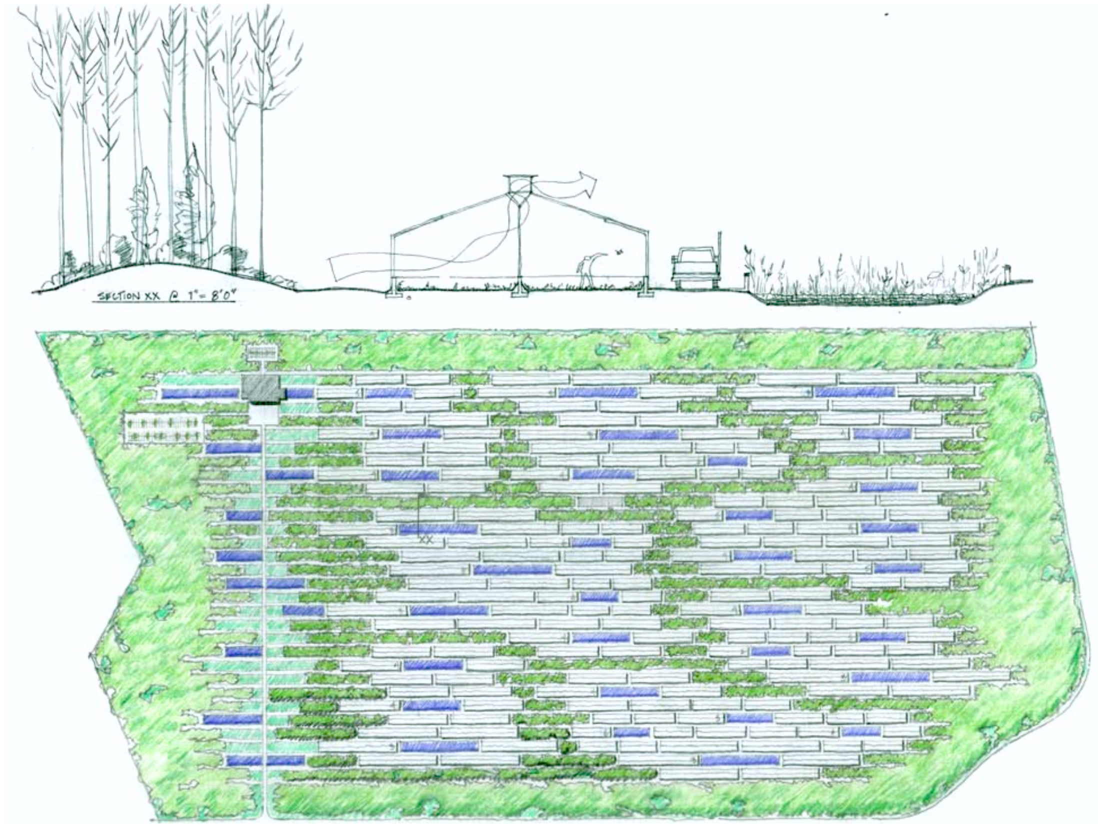


Figure 47 - Site Scheme 5. Author illustration.

Upon review, this strategy suffered in a few ways: 1) the greenways were not wide enough to accommodate real animal movement whether it is seasonal or migratory. According to empirical research, the width of a movement corridor is a matter of tens of meters.[35] It's therefore likely that 42 feet (1 program bay) would not be wide enough to allow for real animal movement. 2) The wetlands did not locate at the periphery of the raceways clusters such that they shared adjacency with the greenways. Animals drink from these wetlands (the salinity content in parts per thousands is not so great that foxes/deer/other fringe species cannot safely digest it), therefore it would be wise to pair these two features, at least where possible. 3) This scheme would require a clear cutting of the site (to berm site soils and replant the loblolly greenways at a raised elevation), thereby eliminating any of the 30+ year old forest canopy (a non-starter). 4) This scheme does not provide adequate

[35] Foreman, 155.

workspace for the cleaning of the raceways after they have been emptied of their water and their crab contents. There would be a real need for open space, or “lawn” elements adjacent to each of the raceways that could be used to abandon plant and regrow the aquatic plant life which would act as habitat during the next growing season. 5) This scheme does not take into account the extremely long shadows thrown by the loblolly trees which grow upwards of 80-100 feet and sometime reach even 120+ feet. The glass enclosed raceways therefore cannot be located directly to the north of the greenway elements. 6) This scheme employed raceways of different sizes in an effort to feather the edge of the raceway clusters. This level of complexity is ultimately unnecessary because the same goal could be achieved using a single raceway prototype and modifying the grouping of these raceways to achieve the same goal.

Site Scheme 6 aimed to remedy the shortcomings of the fifth scheme, but ended up regressing in several regards. While it did make up for a few of Scheme 5’s deficiencies, it was problematic in terms of both the truck routing and the aesthetics of the experience (fig. 48). The relocation of the building from the northeast corner down to the midpoint of the site was not beneficial, because it only complicated the movement of trucks about the site, particularly in the northwest corner. The determined effort to render the raceway clusters more figural in their general outline and shape was equally misdirected. But it was upon viewing this figural solution which finally drove home that it was not the delineation between raceway figure and greenway ground that should be pursued, but rather the blurring of this distinction.

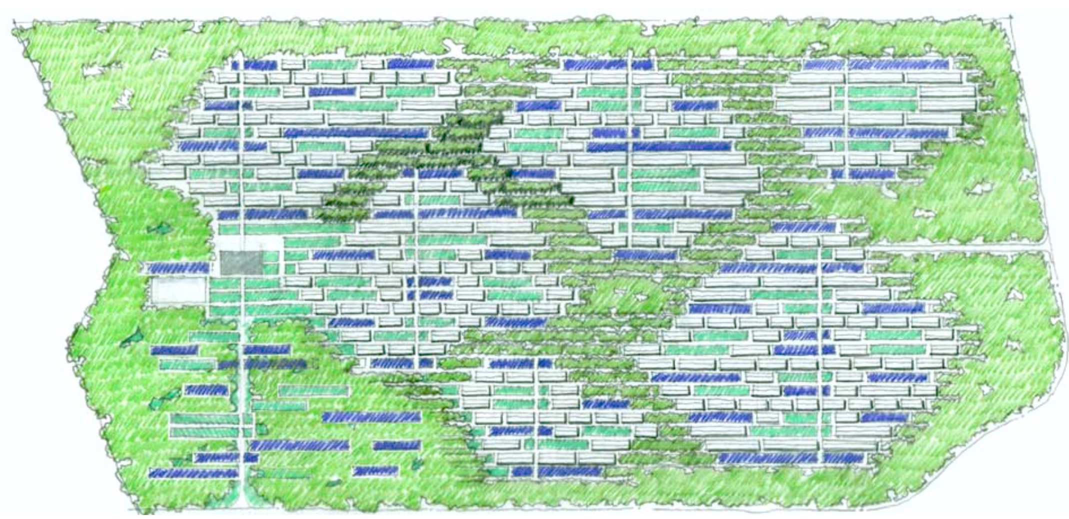


Figure 48 - Site Scheme 6. Author illustration.

As such, Scheme 7 would feature both an afigural grouping of raceways and a feathering or overlap of forest and raceway (figure and ground) that would lend the final scheme its textile-like quality.

Site Scheme 7 made a determined effort to envision the greenway as figure, not the raceway as figure (fig. 49). As the greenway was thickened and the rigid hierarchy of east-west streets was broken, the forest congealed to the east and the west of the site, and the greenway began to balance the raceway clusters in size. The greenway never fully became figure in the ground of the raceway clusters, but the effort resolved many of the issues that had detracted from earlier schemes. Scheme 7 resolved the lingering truck routing issues by adding a secondary north-south roadway to the west of the honorific (visitor) axis. This gesture successfully closed the truck routing circuit in such a way that the trucking would be performed on the site in a clockwise fashion. Instead of breaking the honorific "street" every 42' with a roadway, the service roads begin to aggregate and collect the east-west service roads such that these roadways merge and cross the honorific axis at only four locations. A similar strategy of aggregation was used at the east of the site to avoid penetrating/paving the forest where unnecessary.

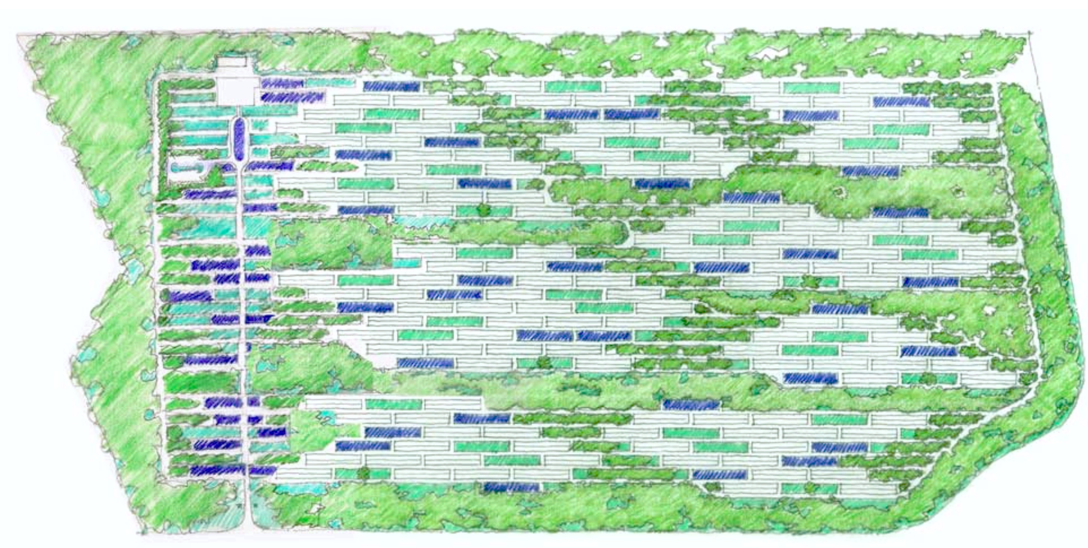


Figure 49 - Site Scheme 7. Final product of iterative process. Author Illustration.

DESIGN PROPOSAL

The proposed design solution envisions the site as a series of three overlapping layers—1) natural forest, 2) manmade farm, and 3) manipulated topography (fig. 50). Although each of the three layers are modified by man's intervention, the forest and the topography are essentially landscape elements, while the farm takes on an element of the landscape only in its relation to the other two systems. The diagram is stratified in terms of elevation (highest layer on top, lowest layer on bottom), but also in terms of use. The manmade farm layer is sandwiched between the forest and the constructed topography, because the farm is essentially a monocultural island in a sea of biodiversity. When the systems are collapsed, the monoculture is essentially perforated by and intermixed with the ecological biodiversity of the forest/topography.

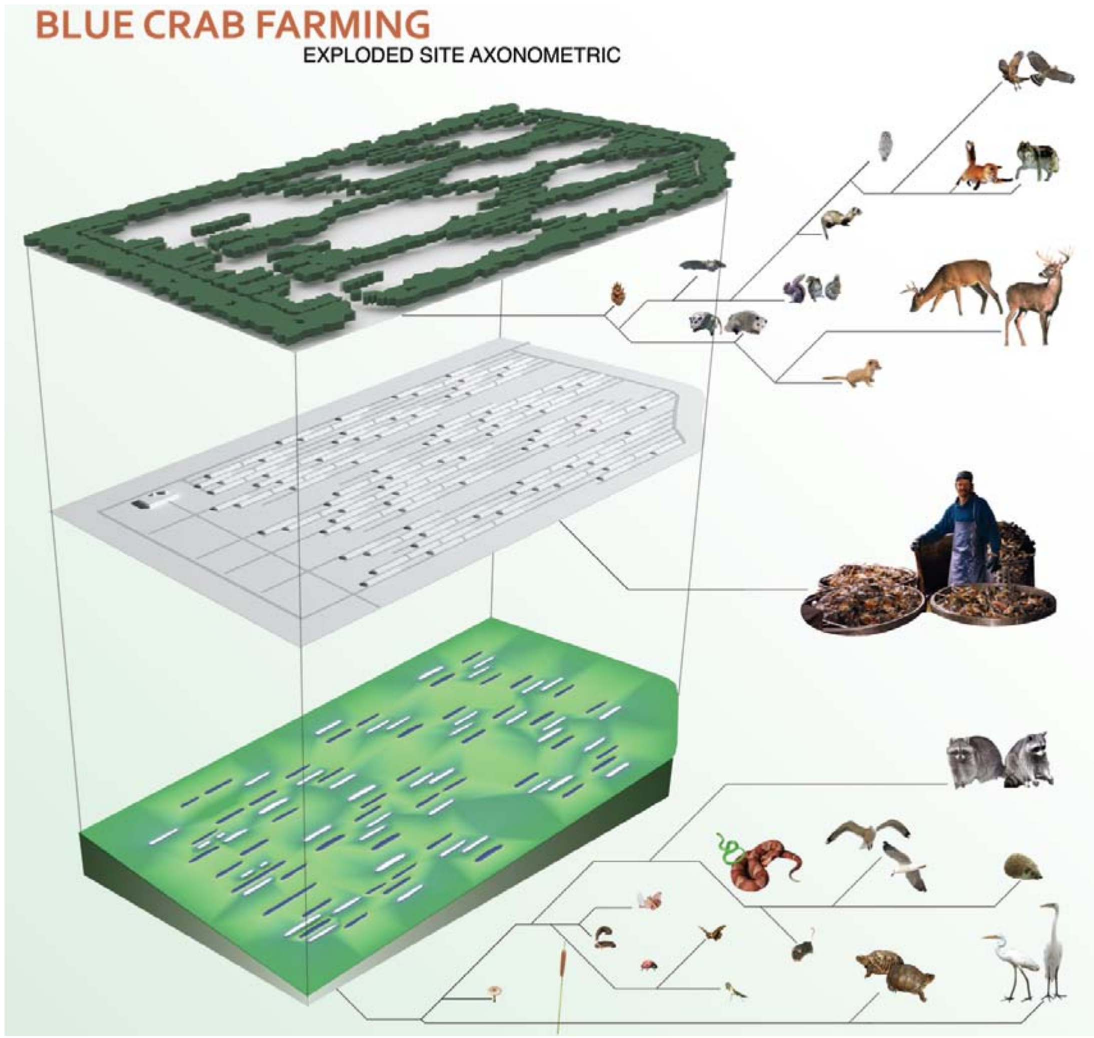


Figure 50 - Exploded Site Axonometric. Author illustration.

The existing forest represents what is believed to be some 30+ years of loblolly growth. In keeping with the thesis, the project attempts to leave as much of the existing canopy undisturbed, in the hope that the species which inhabit this forest currently might remain, at least in part. As stated earlier, the forest is networked in a node/corridor arrangement which allows for at least 3 different paths from every nodal convergence of greenway corridor. It is assumed that over time, this greenway network will not only play host to several resident species, but will also allow for movement of several itinerant corridor (edge) species such as deer, foxes, etc.

The manmade farm is an imposition of a regular system upon an otherwise natural land mosaic. This layer consists of the stone roadways, the glass enclosed raceways and the crabs they contain, and finally man. This system is specifically intended to discourage unwanted predation. Aside from thermal regulation, this is the reason why the raceways are roofed with glass. While the wetlands will encourage birdlife, the greenhouses are intended to minimize avian predation.

The constructed topography is the result of the manipulation of the existing ground plane. The site slopes very slightly to the southwest (a delta of only -2'0"), and can be thought of as if flat. For this reason, it became very important to construct the localized wetland features in such a manner that the cut from these ponds could be used nearby as fill, thus preserving net-zero balance of site soils and eliminating the need for haul or import.[36] This layer would play host to a variety of native and migratory species. As the wetland component can be seen from above, birds of many types would use the site both regularly and seasonally. The meadow components would not be mowed, and would therefore resemble grassland habitats. Over time, the accumulation of debris from the raceways could potentially be reharvested as a revenue-generating source of organic mulch. With the proper care, it is also believed that the meadows could grow the vegetation which could be transplanted into the raceways at the crab harvest and be used as the submerged aquatic vegetation (SAV).

The final site plan (fig. 51) shows the various systems working together at 1" = 100'0". At this scale, the site retains a liminal quality of being both diagram and reality in one. The clockwise routing of the trucks becomes apparent, as does the required 28' turning radius (modeled on the Toyota Dyna or the Isuzu F-Series). These turns terminate the allés so that the forest can bleed together across the rigid boundaries established by the roadways, but they also allow trucks to double back on themselves if a driver has made a turn in error. At the 1" = 100' scale, we begin to be aware of localized site variances where raceway clusters are split to allow for views. This strategy was pursued in order to alleviate the monotony of the experience within a particularly dense portion of a particular cluster of raceways. Instead of walking along greenhouse after greenhouse, the occasional splitting of the raceway clusters allows for long views terminated against water, meadow, and forest. It is believed that this deviation from the rigidity of the organizing system would both mitigate the perceived density of the raceway clusters and dramatically enhance the users' experience of the landscape.

---

[36] In Maryland, hauling operations can run anywhere from $17/c.y. to upwards of $24 (Author's GC experience 2007-2009).

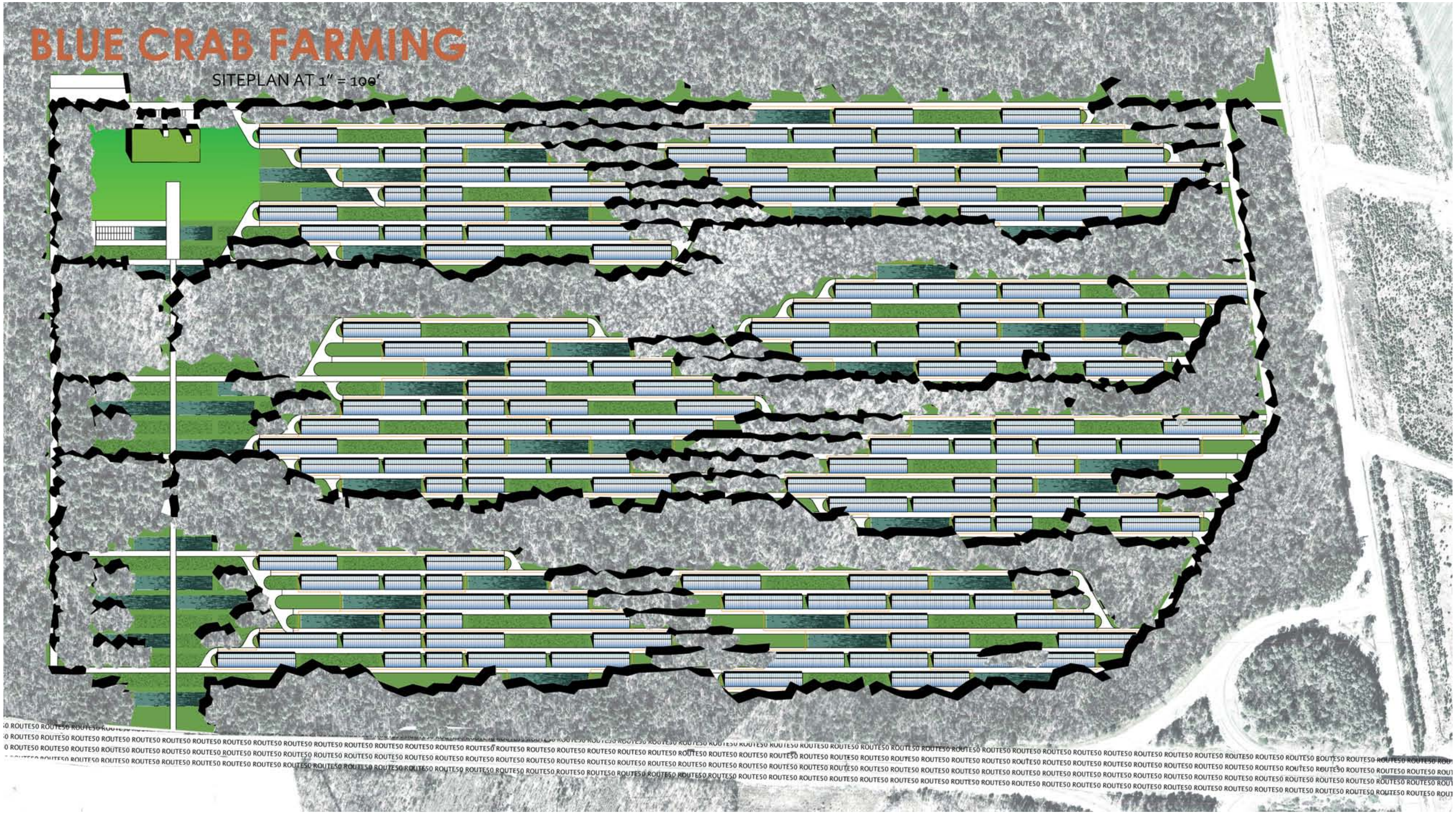


Figure 51 – Final Landscape Design. Author Illustration.

When first stocked, each raceway is home to just under 10,000 blue crab juveniles. Over the course of the next 3 months the crabs will grow to full size, but their numbers will decrease significantly due to cannibalism. With an assumed attrition rate of 75%, each raceway should yield some 2,400 blue crab adults on harvest day. Given a year-round staff of 30 pickers, each of whom can pick a minimum of 20 crabs per hour, two raceways are harvested, picked, and processed each work day. With a 4 season turn-over, 124 raceways, or 31 4-unit clusters are necessary to provide the pickers with the 1.2 million blue crabs (or 400,000 lbs of crabmeat) they will process over the course of the year (fig. 52).

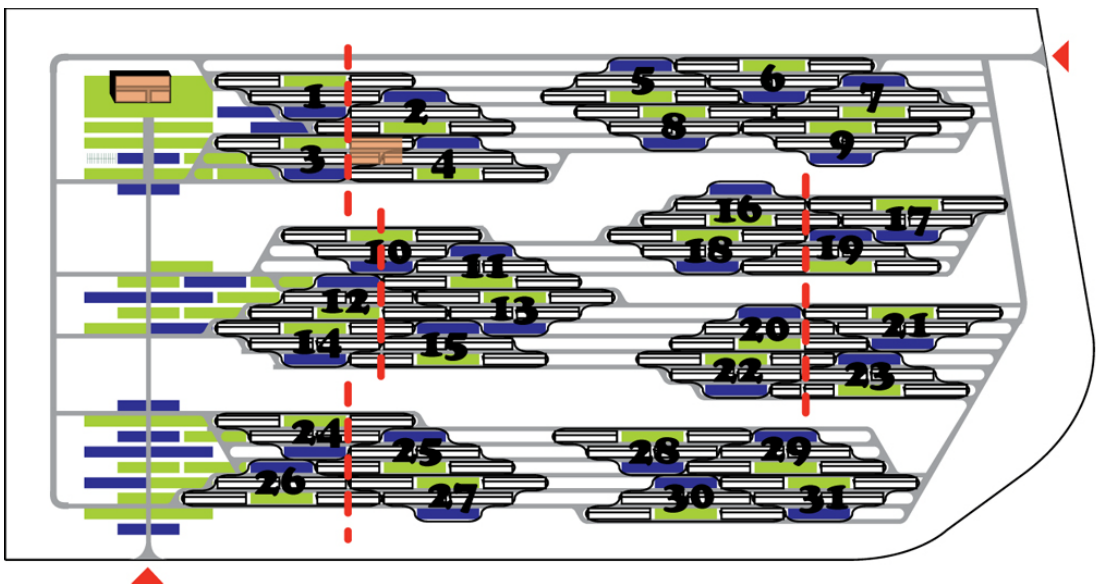


Figure 52 – Site Diagram. Author Illustration.

The raceway clusters are an assembly of one basic unit type that consists of 4 raceways paired with a wetland and a work meadow (fig. 53). This pairing is important because each raceway requires a direct adjacency to the meadow so that debris from the raceway can be deposited on the meadow at the end of each harvest and newly grown vegetation can be transplanted in the cleaned raceway. In order to provide for successful drainage, each raceway must be close enough to a wetland to allow for negative outfall. These units are assembled in a staggered manner similar to the technique by which the basic unit is assembled, meaning that the raceways do not align vertically from row-to-row but are offset by half a greenhouse module.

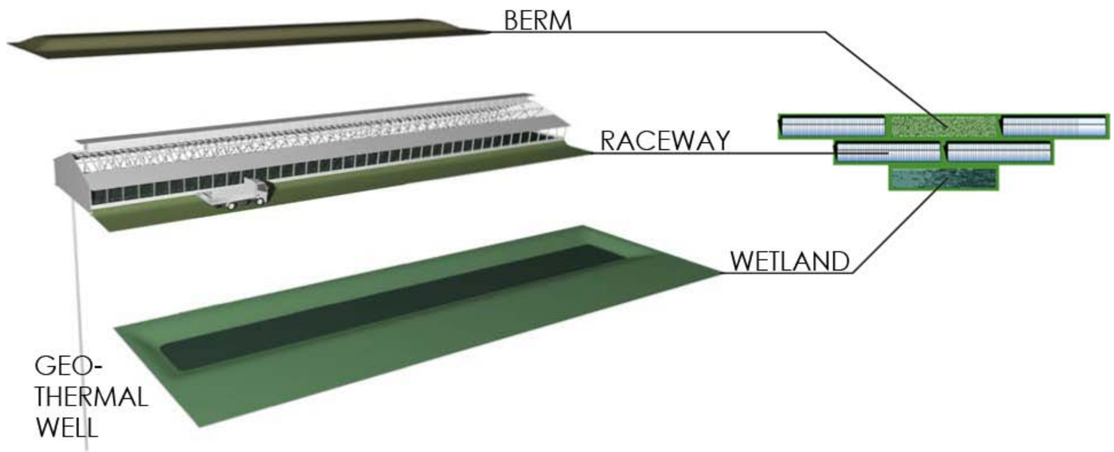


Figure 53 – Unit Module. Author Illustration.

As mentioned previously, the site itself is decidedly flat, and this is best depicted in site section AA, which features some 12 unit bays of the system (fig 54). The flatness of the site is contrasted by the outcroppings of loblolly, whose towering presence serves to frame and mask this flatness. This section reveals the distribution of water across the site, where it is raised within the raceways and where it is depressed in the wetland features. The use of these water features in particular changes according to the time of day. During the daytime (fig. 55, section CC), the site is a working farm trafficked by trucks and harvesters, student groups and conservation biologists. But when dusk falls and the site grows dark, the nocturnal inhabitants of the site begin to move about, circulating along the greenways and drinking from the wetland features.

The raceway garage doors are opened and closed based upon the time of the day and year. During the summer months, the raceways' doors are rolled up to allow for air to pass freely through the structure (fig 55), but at night and during the winter, the raceway doors are shut. During summer nights, the raceways are closed in order to discourage night predators. During the winter, the raceways are closed so that enclosed air might be heated by the sun during the day and retain some warmth over the night. The visitor can always orient himself on the site based on two important features: 1. the north facing vents which exhaust hot air during the summer months. 2. The difference in garage door materials. The roll up doors to the south are glazed to allow more light into the structure, while the roll up doors to the north are wood.

Thus, a visitor walking down an east-west road should be able to ascertain north based strictly upon material cladding of the raceway structures.

The pre-manufactured gutters act as sunshade allowing for winter sun, and blocking summer sun (fig. 56 section FF). The bottom of these overhangs is 10’0” above the existing grade, a height which provides a human scale to the raceway, but also acts as a stop for crabs as they are physically tossed out of the raceway structure. The 20’0” tall roof vents crown a raceway unit that measures 42 feet wide, and 240 feet long. These dimensions are not arbitrary. The 42 foot width was arrived at by determining the average distance a man can comfortably toss a crab (approximately 20 feet, or ½ the raceway). The 240 foot length was arrived at by looking at how many crabs would be necessary to employ 30 fulltime pickers. The 4 foot tall concrete raceway walls are insulated against the cold using earth berms that will grow meadow grasses on the south side of the raceway more shade resistant groundcover on the north.

Although this berm prevents the visitor from promenading directly alongside the raceway, each raceway is equipped with several sets of stairs that are used by the harvesters to climb into the raceways and the visitor who wishes to peer into the raceway to view the crabs in their reconstructed habitat. The 18’ roadway was designed with truck travel in mind, but it wide enough for a truck to travel alongside a pedestrian without too much trouble. This was an important consideration because the site must work mechanically as a working farm while at the same time accommodating various scientific and educational use groups.

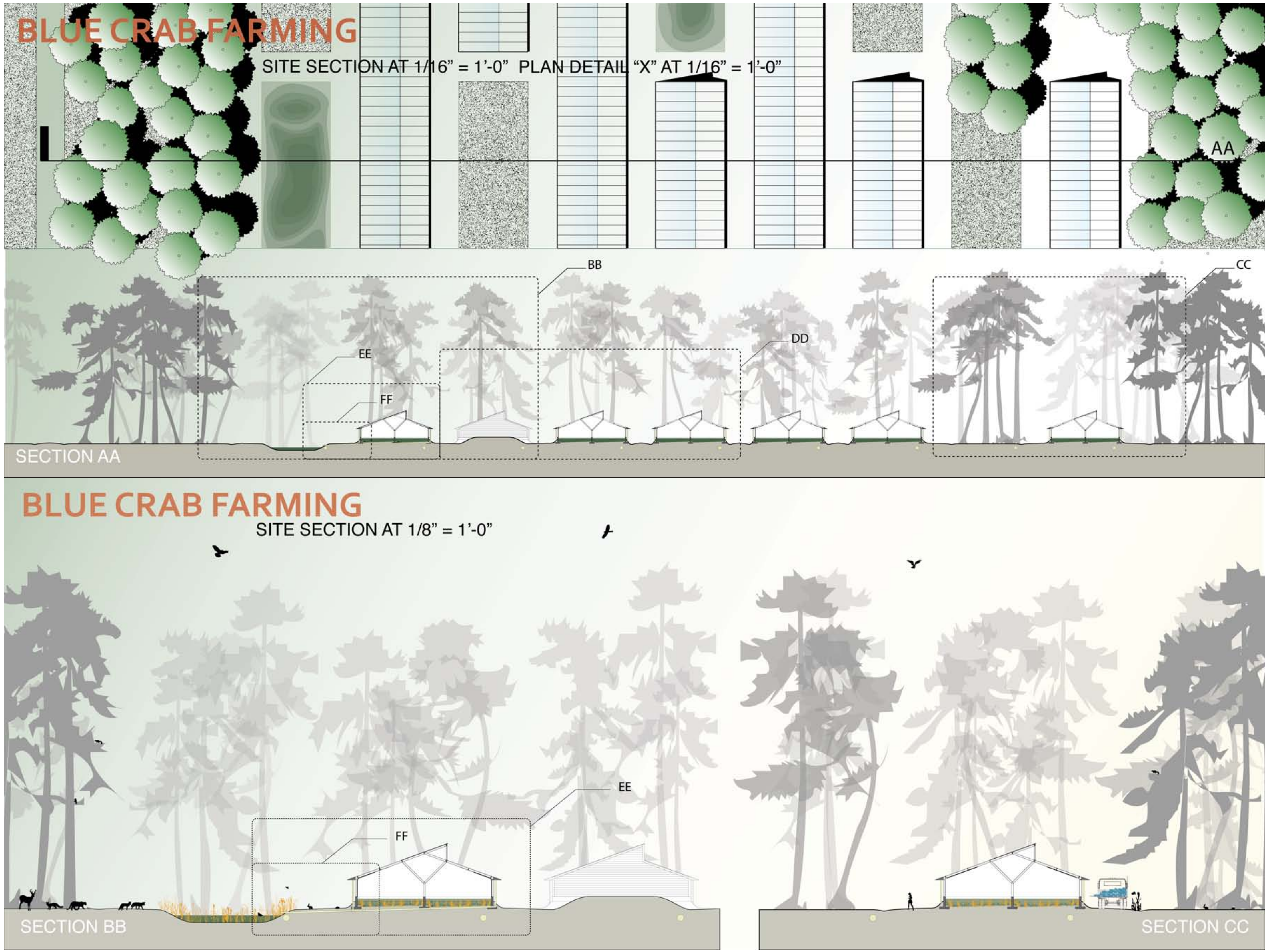


Figure 54 - Plan Detail "X", Site Section AA, BB, CC. Author Illustration.

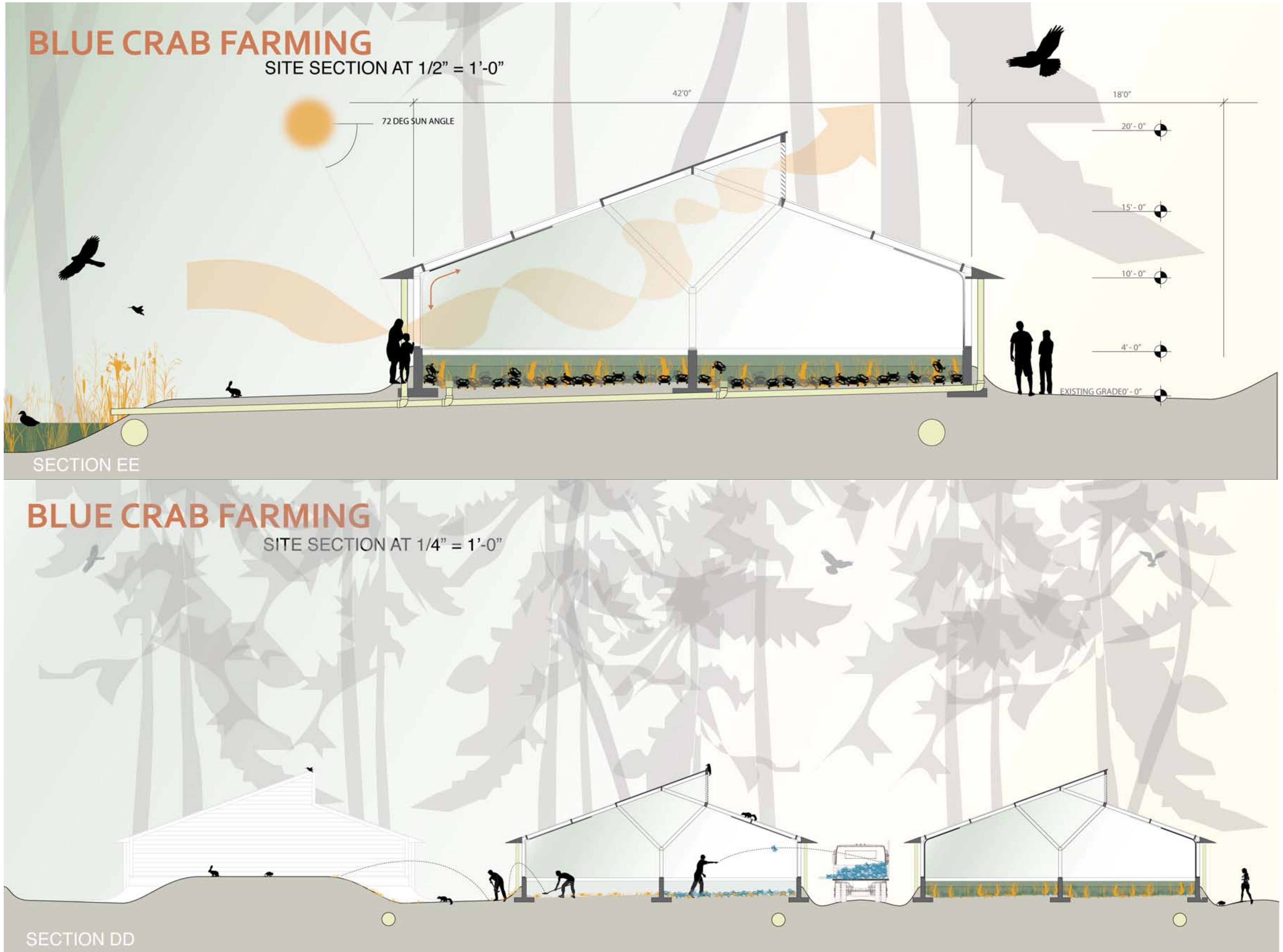


Figure 55 – Site Section DD, EE. Author Illustration.

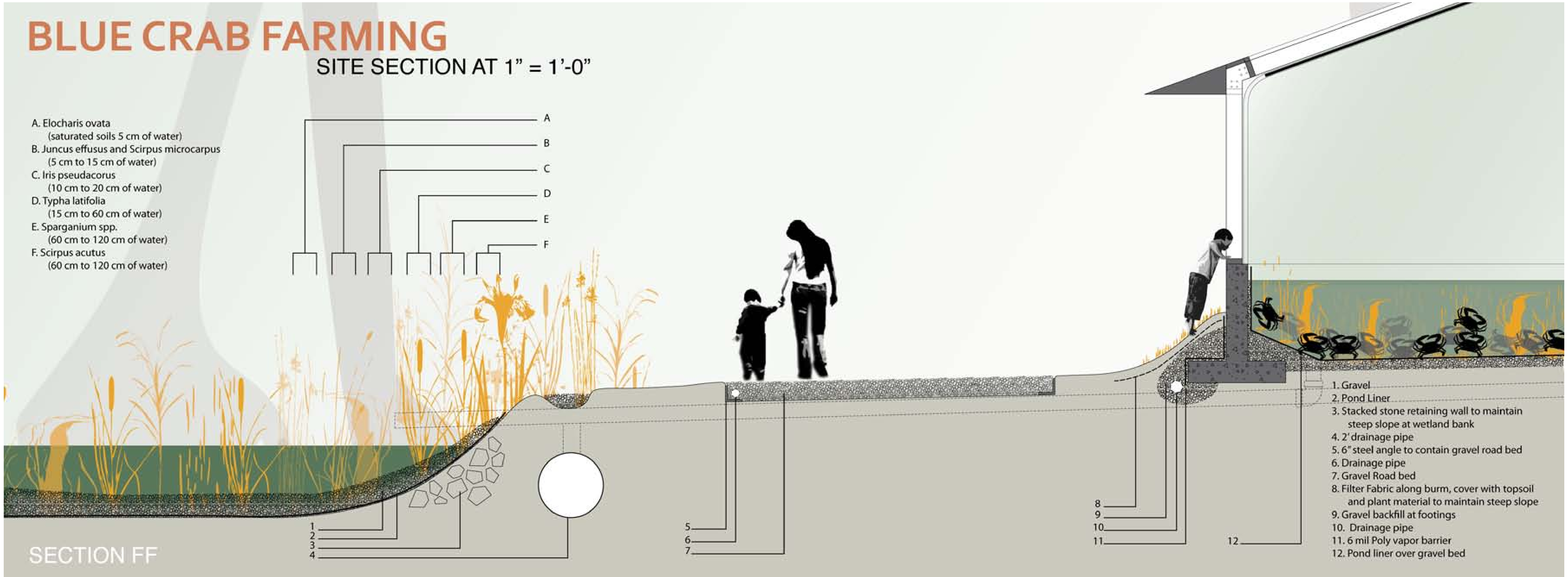


Figure 56 – ***Site Section FF. Author Illustration.***

The farm complex itself (not including the surrounding forest) takes up a footprint of 2/3 of a mile by 1/3 of a mile. This area equates to approximately .25 square miles or 160 acres of developed footprint. As such, it is important to understand that the sheer size of the developed footprint could be daunting and perhaps even staggering if agglomerated in one mass of building. The introduction of the greenways into the interior of the farm was intended to allow other forms of plant and animal life to inhabit the farm, but it had a secondary impact on the way we experience the site. As the greenways were thickened during the design process, and began to engulf the individual clusters of raceways, not only was the size of the operation camouflaged in plan, but the vast size of the operation was mitigated in the ground plane. The experience of moving through the site would be something akin to passing though a sparse forest canopy and emerging into a clearing populated by glass enclosed raceways, lush wetlands, and grassy meadows. The dramatic height of the loblolly forest and its encircling of the raceway clusters frames site views such that there is always a foreground (wetland and meadow) a middle ground (raceway), and a background (forest). This strategy's placemaking is evident in the site perspectives that have a rooted quality, one which would be impossible without the dissection of the program into small, self-contained clusters.

As architects, we tend to think of our projects in terms of how we use them--particularly how we use them from 9 A.M. to 5 P.M. Nature doesn't work this way. As such, the project had to be developed in such a way that it can work in all types of diurnal conditions. By day, the farm is "worked" by 6 or 8 journeymen—draining, harvesting, cleaning, and restocking the greenhoused raceways (fig. 57). By night the site is occupied by the nocturnal animals—owls, foxes, deer, possum, drinking from the wetland features and moving along the greenway corridors (fig. 58). The project works during the summer and during the winter, although the user groups change (figs. 59 & 60). Most importantly, the site is designed to work during drought, and during 1000 year storm conditions (figs. 61 & 62). By setting the top of the concrete walls at 4'0" above the existing grade, the site can withstand several feet of floodwater without losing the crab harvest. The journeymen could either wait for the waters to subside, or harvest the raceways using shallow-hulled boats.

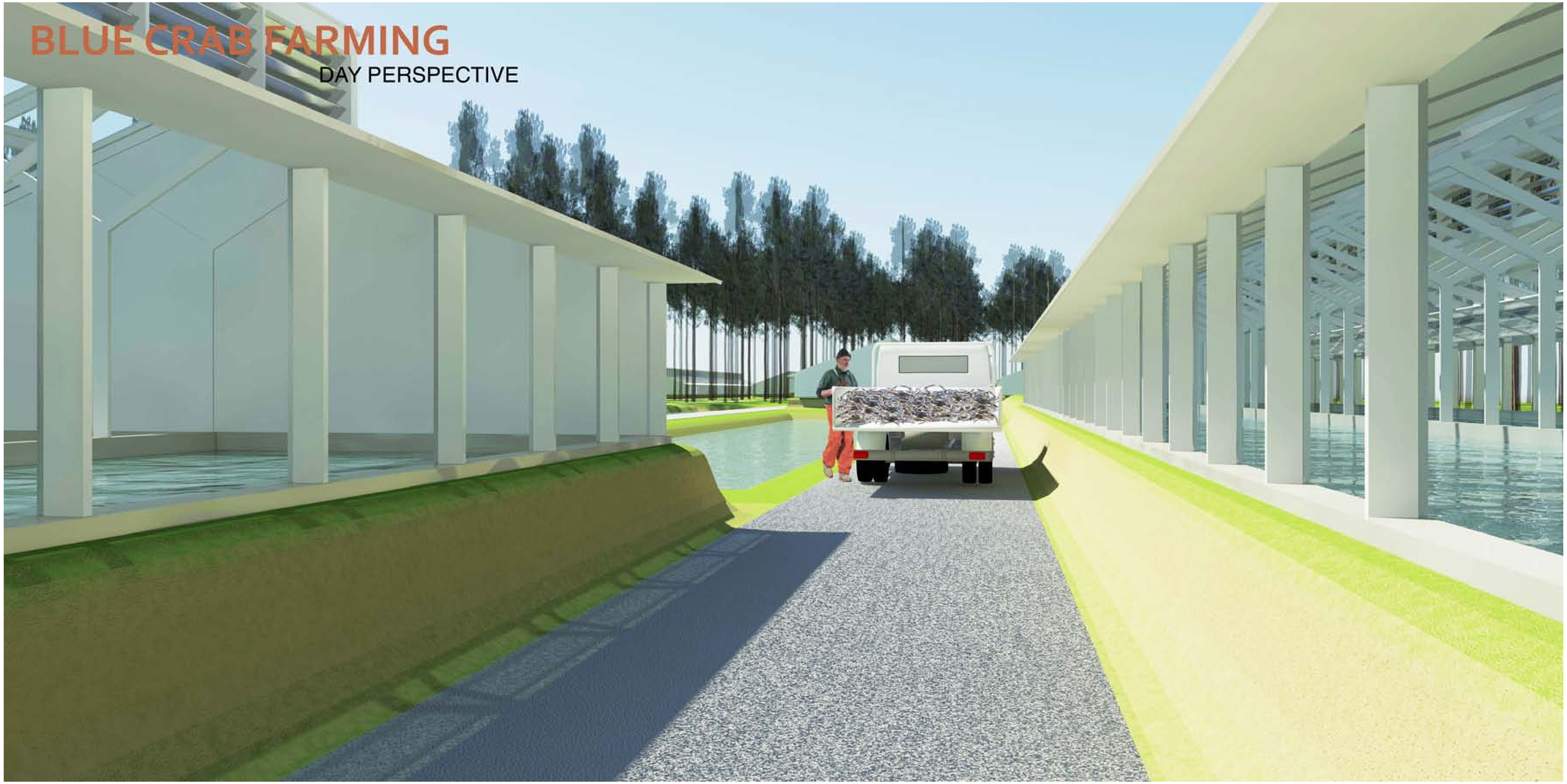


Figure 57 – Daytime Perspective. Author Illustration.

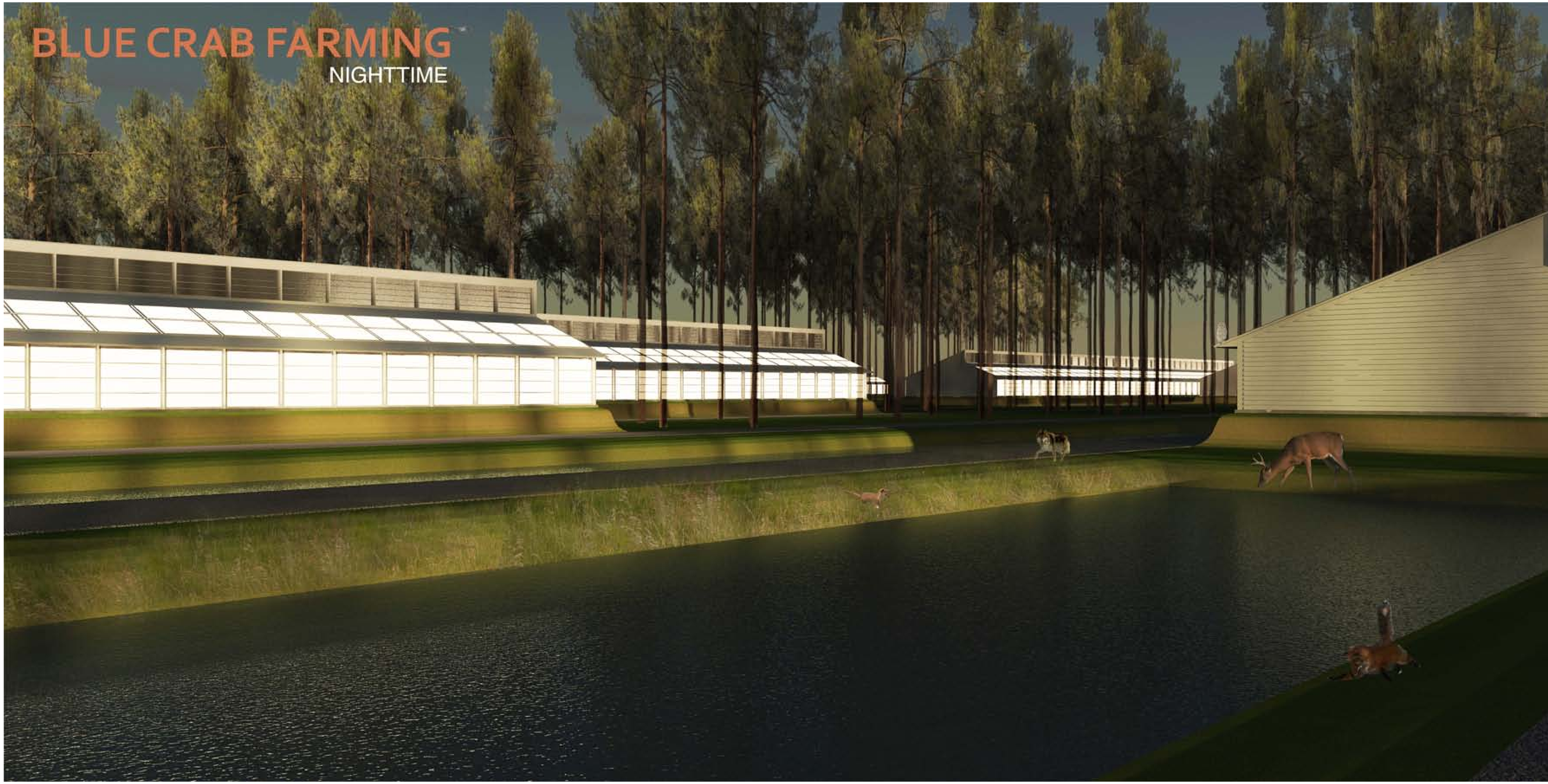


Figure 58 – Nightime Perspective. Author Illustration.

Figure 59 – Summer Perspective. Author Illustration.

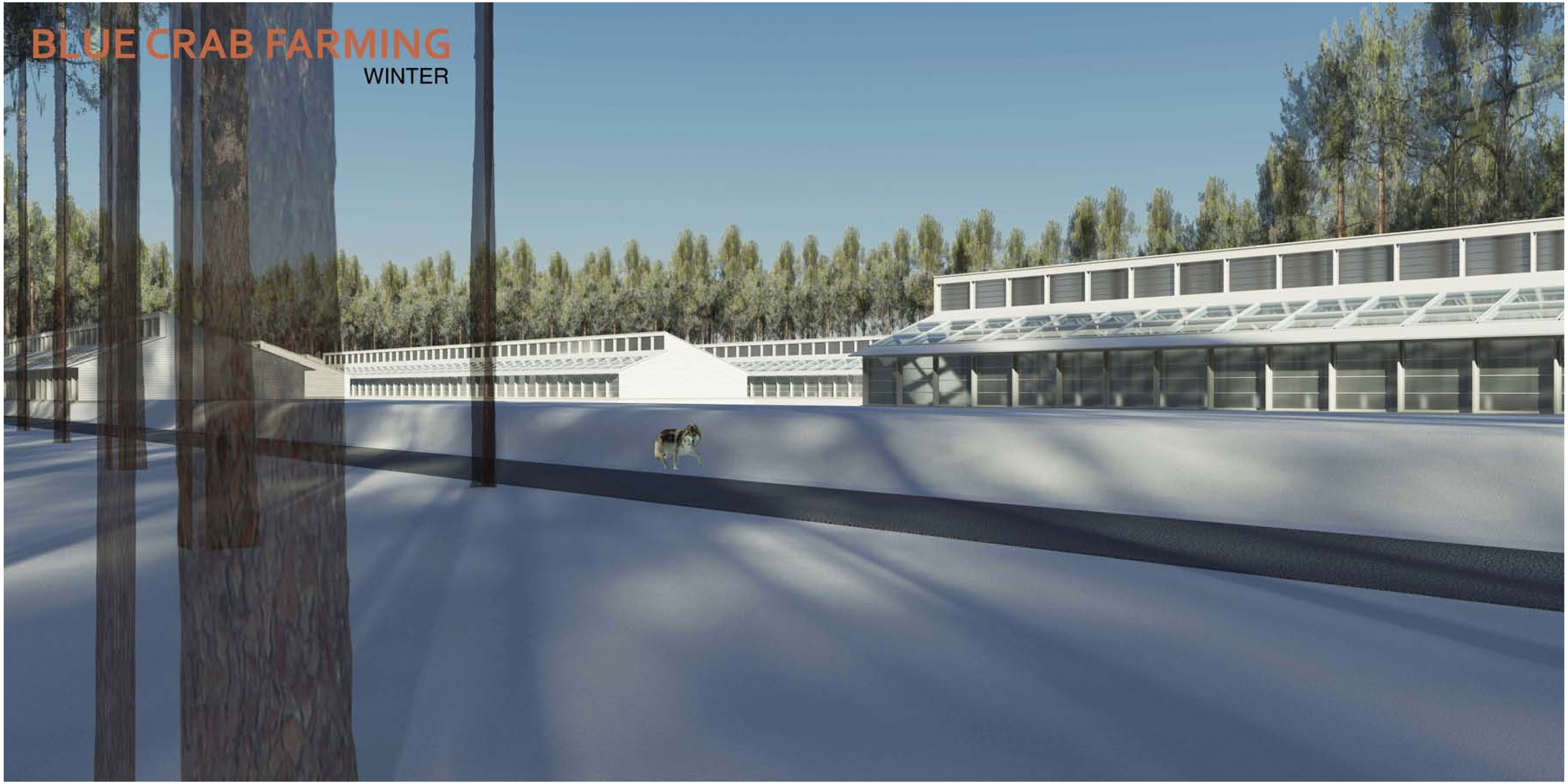


Figure 60 – Winter Perspective. Author Illustration.

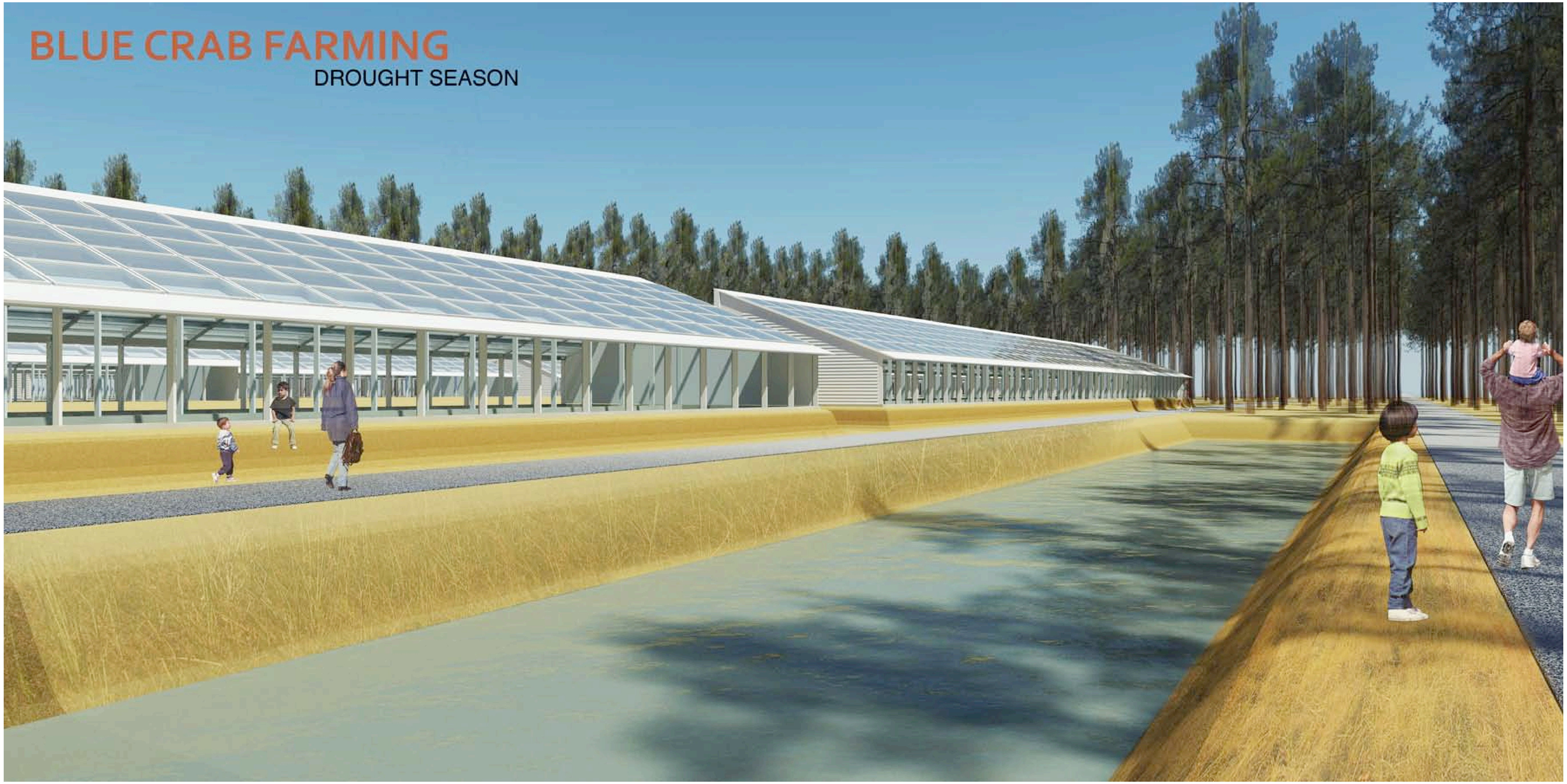


Figure 61 – Drought Perspective. Author Illustration.

Figure 62 – Flood Perspective. Author Illustration.

The visitor’s approach road (fig. 63) is a long allée terminated by the building, which is raised above the existing grade by 4 feet of terraced ground. From this elevated position, building surveys the 18’ wide bluestone roadway along which the visitor promenades. This allée is characterized by changing conditions where the forest advances to engulf the roadway, then recedes to create clearings populated by berms and wetlands (fig. 63). These wetlands/berms meet the roadway in different ways. Sometime the roadway penetrates these features, and other times these elements shy away from the road. These features are not purely scenographic, although they do lend the path a cinematic quality. The water features are actually networked with the wetland features distributed throughout the site such that in the case of a flood or rain event, the wetlands are capable of filling beyond capacity without overflowing onto the east-west roadways. Individual ponds are tied together with galvanized utility piping that connects at the west of the site to the water/overflow features.

The visitor’s path to the building is penetrated only five times by the east-west collector roads that terminate in the north-south service road leading to the facility. At these junctures the visitor has a view to the east into the working farm, where he/she will first glimpse the reflective form of the glass enclosed raceways. As the visitor nears the facility at the end of the roadway, the forest expands to the edge of the roadway to force a perspective of the building as it surveys an expansive forecourt. After the abrupt termination of the forest, the visitor crosses between a final set of wetlands and berms, and finds him/herself in a terraced landscape that consists of a succession of natural grasses planted in such a way that they echo the horizontal banding of the road grid. After dropping off passengers at the front of the facility, the visitor’s vehicle turns to park in a stone parking area to the southwest.

From the exterior, the building reads as a single box topped by two service towers. The exterior envelope consist of alternating planes of floor to ceiling glass and something more opaque, perhaps brick or wood siding. These glass walls step in and out based upon the uses contained within. The programmatic relationships are very much determined by the functional working of the building. The algae tanks that fuel the laboratory foodcycle are located on the southern curtainwall to take advantage of the southern sun. The lab offices and managing director’s suite are also located on the southern curtainwall to take advantage of this natural light, but these programs are set back within the volume of the box in order to take advantage of the roof as shading device.

Figure 63 – Perspectives Along Allée. Author illustration.

These offices are also equipped with light shelves to mitigate the vast amount of light penetrating the southern façade. The picking and processing operations are located on the north side of the building to allow for indirect illumination of the workspace. As the picking floor is 6 feet below grade and the window wall begins 4 feet above grade, the pickers direct views of the landscape are minimized. This elevation allows the pickers views into the field of loblolly trunks, without permitting distracting perspectives of the ground plane. The tower elements are located within the depth of the northmost program bar to allow the visitor to access the restaurant and the roof deck without crossing over the double height gallery/corridor space that runs east west along the building's center.

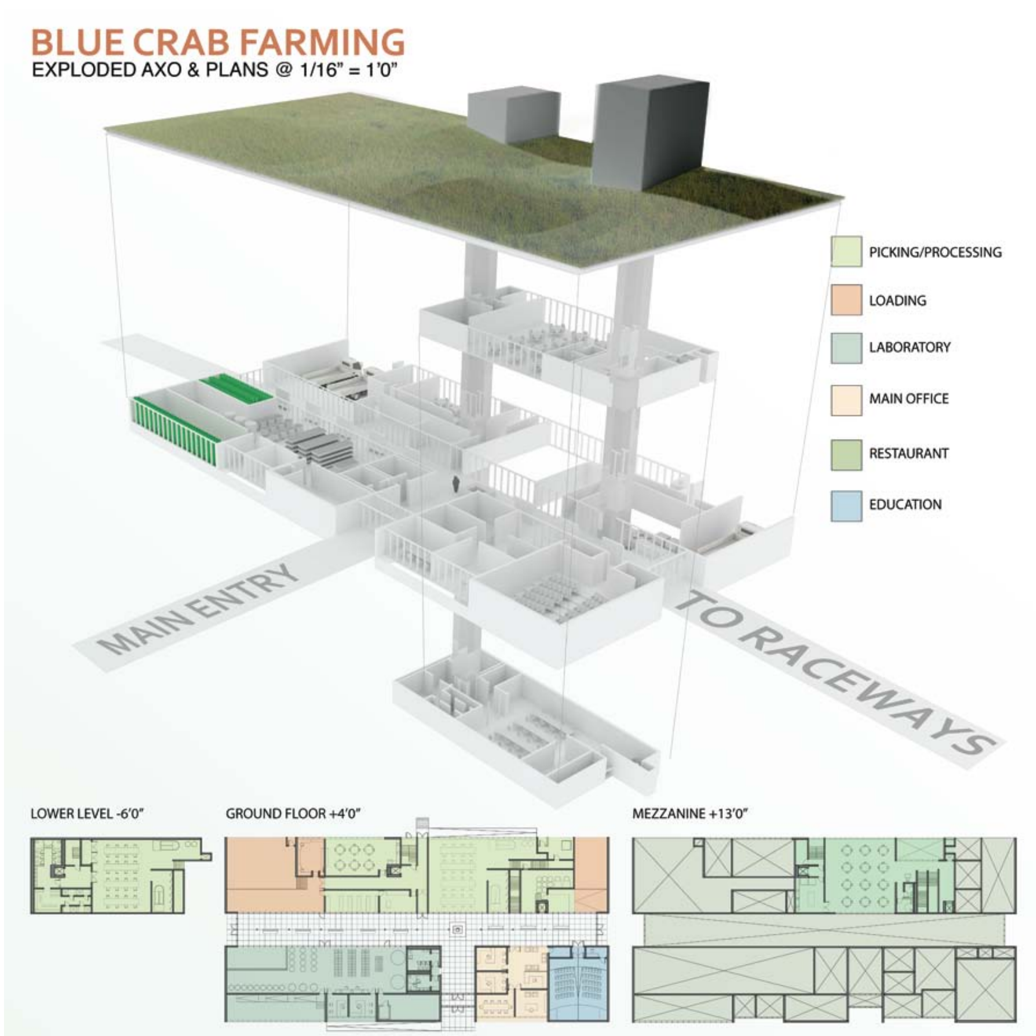


Figure 64- Exploded Axonometric. Author Illustration.

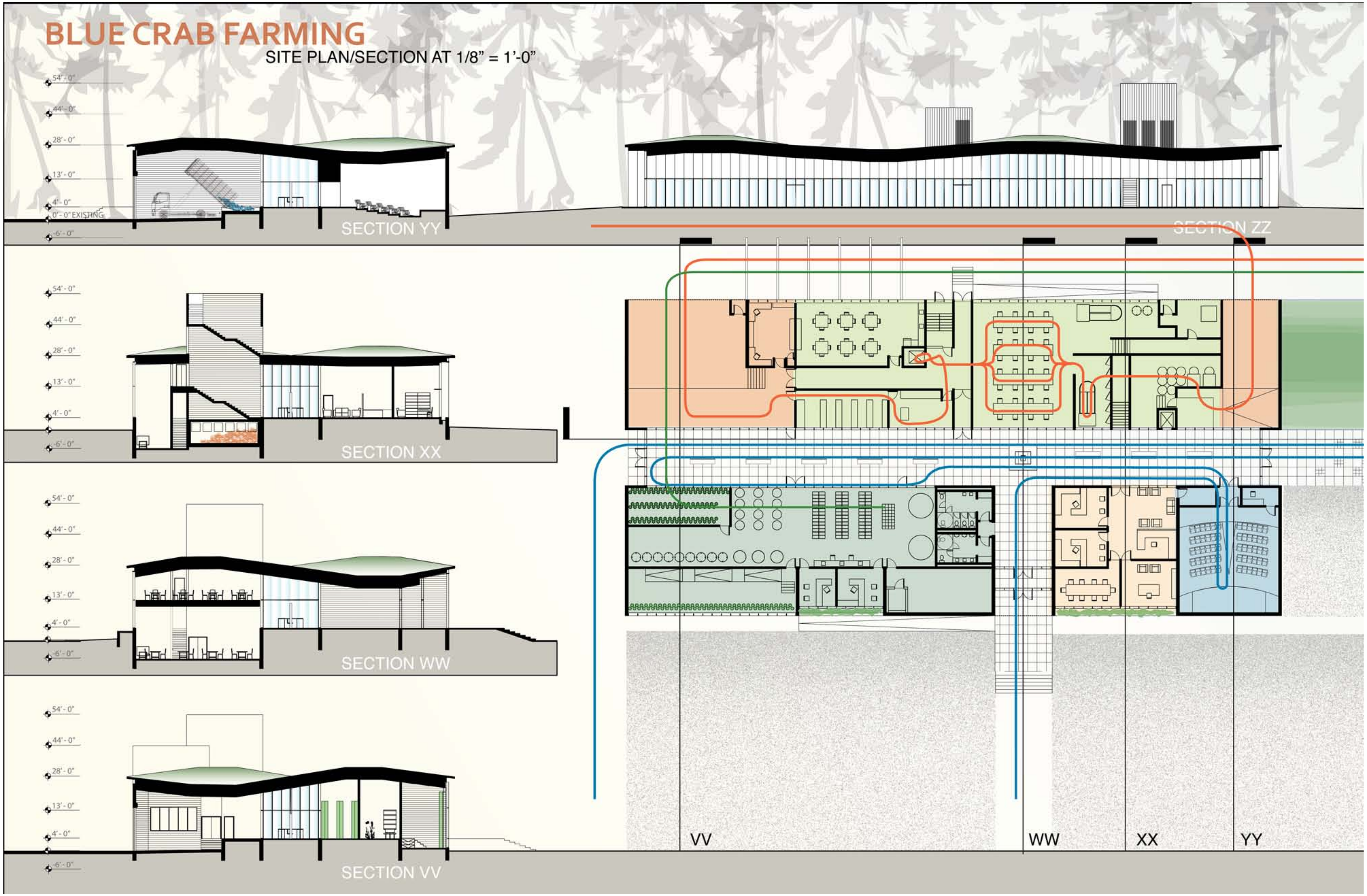


Figure 65- Plans and Sections. Author Illustration.

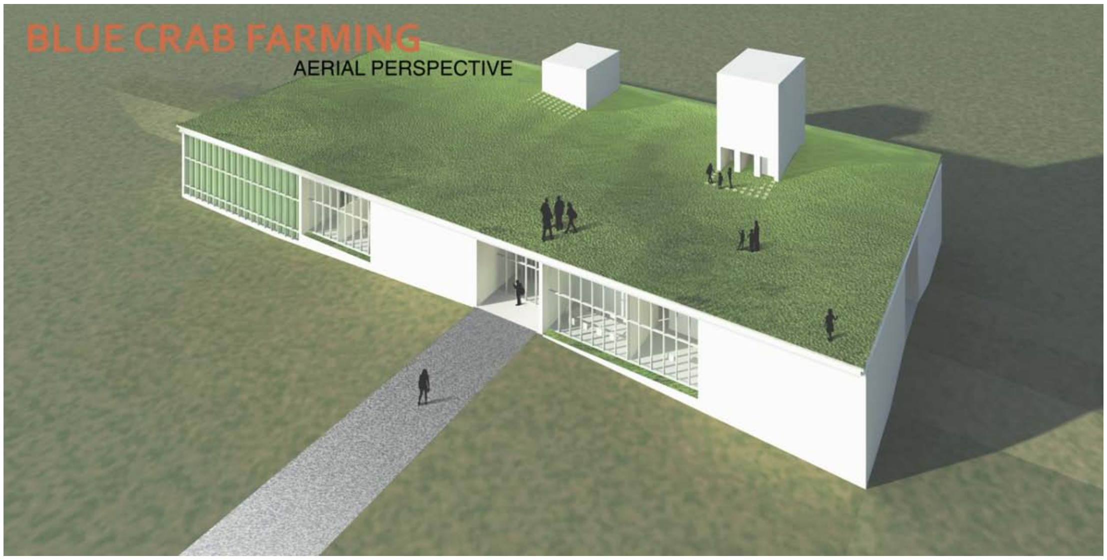


Figure 66 – Aerial Perspective. Author Illustration.

Upon entering the facility (fig. 66), the visitor is greeted with a view into the picking facility and the restaurant above, both of which are glazed to allow views directly through the program and into the loblolly forest beyond (fig. 67). This is important metaphorically, because upon entering the enclosure of building the visitor's view is channeled back out into the natural environment. The central kiosk at the junction of the two corridors serves multiple purposes—acting as information counter, tour ticketing, and sales counter for the various crab products for purchase.

Figure 67- Entry Perspective. Author Illustration.

This termination of the view and extension into the landscape is a classic modern technique of forced perspective, and it is one that works very effectively here. These views into the landscape are marked by the contrast between the austerity of the architecture and the messiness of the picking operations (fig. 68). The landscape beyond simply frames these mechanized processes. The stacking of program achieves a secondary metaphorical goal here. The visitor is simultaneously witnessing the processes of production and consumption. The labor that picks the crabs literally supports the restaurant program in which that same crab is consumed.

Figure 68 – View into Picking. Author Illustration.

As one moves along the central corridor, one becomes aware of the undulating roof surface which telegraphs from the exterior of the building into the interior spaces. This corridor is populated with information boards that double as interactive educational elements and benches set up to view the various lab, picking, and processes activities that take place intermittently all day long (fig. 69).

Figure 69 – Corridor Perspective. Author Illustration.

After paying for a tour and viewing an introductory video in the auditorium, the visitor is escorted along the hallway to the laboratory component of the building where he/she can view the fulltime lab tech feeding and rearing the crabs (fig. 70).

Figure 70 – Laboratory Perspective. Author Illustration.

At the westernmost end of the corridor, the blue crab juveniles are piped from the plexi cylinders across the way and into the northeastern loading dock where they are pipetted into the trucks that will distribute them into the raceways. After witnessing this operation, the tour group goes outside to view the second stage of the crab's lifecycle, the raceway stage. The tour group walks along the stone road and makes a loop around one of the raceways and alongside a wetland while the tour guide explains the working operations of the farm and the biological processes taking place within the wetland. Upon returning to the building, the tour is escorted along the northern glass corridor where the successive stages of processing are catalogued. As the tour moves along this wall, the visitor can watch as the crabs are dumped, sorted, (between sooks, jimmys, and jumbos), steamed, refrigerated, picked, weighed, packaged, refrigerated, and shipped. After eating in the second floor restaurant and/or milling about the roofscape, the visitor has the opportunity to ascend the observation tower which provides panoramic views back into the farm complex (fig. 71). Subsequently, the visitor is invited to take a self guided tour through the farm complex or to purchase one of several crab products on his/her way out of the facility.

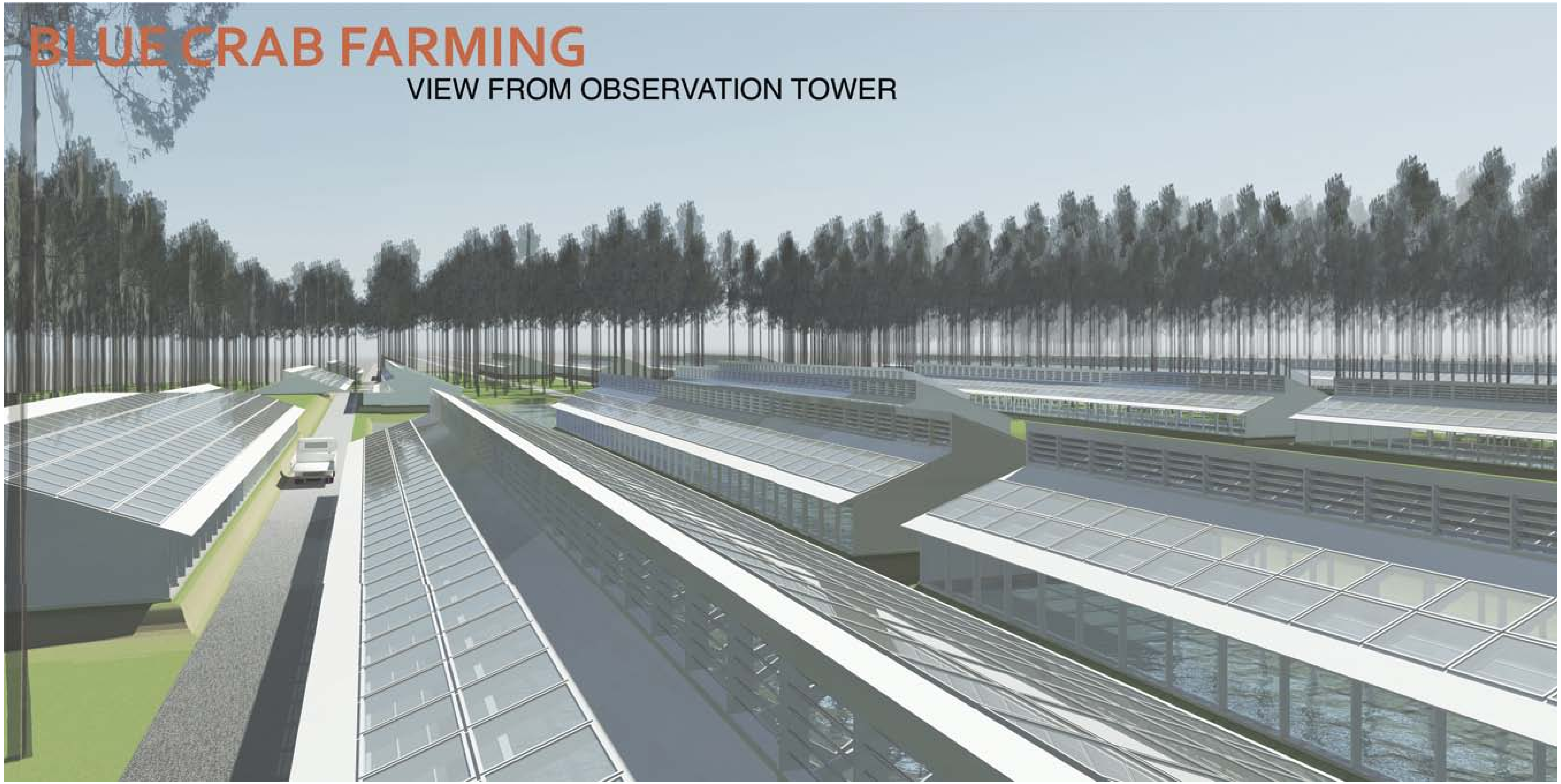


Figure 71- Perspective from Observation Tower. Author Illustration.

Sonja Duempelmann—You mentioned at the beginning that this was a rather strange idea. Well it is a very strong idea, and that's why it's very good, but it is also a very provocative idea. You took a process and designed everything in the building and the site around that process. That's a challenge and it's well done here. But I wonder, at the moment the building and the site are very resolved, can you imagine a way to introduce even more tension into the project?

Alexis Gregory—Yes. In the site, the raceways are offset, or shifted in a beautiful way. Why didn't this gesture make its way into the building plan? The building plan looks like one raceway on top of another, and separated by the roadway…

Justin Donnelly—The building plan actually duplicates the way in which the raceways are organized. The program bar at the top is one full raceway, and the program bar at the bottom is two raceways separated just as they are in the site. It is a cropped snapshot of the raceway diagram.

Steve Ziger—This is a very strong scheme. And I actually respect your intuition in making the factory building one self contained thing. I would resist having it shift or having it respond more to the sheds where the crabs are raised. This site is so large and there is so much going on here that it is important to have a central kind of strong statement of the container, the box, the factory, that these things happen within.

Susan Rogers—Are there some moments in there where the experience of the landscape changes? The pattern that you have established, does it ever change?

Justin Donnelly—There are several localized, unique site conditions. The clusters of raceways have been split where they become very dense to afford the pedestrian unique vistas between the raceways and into the wetland/berm/forest. This would enhance the experience of the site.

Steve Ziger—I like the layered quality to the site, the topography, the machine of the sheds and the landscape that begins to connect the habitat. That is starting to happen in the main building, in the [undulating] roof, but it may be more explicit in the ground plane as well. As you mentioned, you have all these different elevations going from the loading down 10 feet. Maybe you can use that topography to make a little more sense out of that level.

Michael Ambrose—Justin began by describing how our society is basically destroying itself and the Chesapeake Bay along with it. I think the part of the power and potency of this project happens right here in the site section where we see a child peering into one of these raceways and looking at the blue crabs. Or the section that shows a mother and a child walking along the edge of a constructed wetland. There are very few places in the built environment that invite people up close against this edge of natural grasses digesting natural wastes. To give people the opportunity to see this is really quite powerful.

Michael Ambrose—This site connects the visitor to the forest, the wetland, and the meadow. The building connects the visitor to a series of mechanized and human crab production processes. And the views along what I like to call the glass "nose" wall would be fantastic. Positioning us between nature and the blue crab, well that's a nice place to be, and I want to thank Justin for taking us there.

Design Conclusions

The juried debate consisted of comments that could be delineated into two categories: substantive and representational. The substantive comments are catalogued above, while the representational comments have been included below. Upon review, it became clear that the manipulation of the grade changes within the building could have been made even more self-evident. This could have been achieved by ramping from the picking/processing areas up to the weigh/refrigeration program along the "nose" wall and/or changing the orientation of the steaming process so that it moves right to left. After the jury's debate over whether the facility could have been made more dynamic by offsetting the programmatic volumes from one another, there was some consensus that the box was probably a stronger gesture—certainly functionally and possibly even representationally. At the final review, the thesis committee suggested that the undulating roof wasn't actually doing anything that a flat roof couldn't. It was therefore suggested that the roof be redesigned into a minimalist flat green roof. This point is very valid, especially taking into consideration that in the real-world, the best one could hope for in a for-profit venture would be a flat green roof (seedum only) on light gauge metal trusses or steel I-beams.

Representationally, the working of the farm/building is complex enough that it would benefit from movement diagrams within the floor plan. This was added subsequently to the juried review. The manner in which the building sits within the landscape and interfaces with the terrace/raceways required some further exploration. The routing of the trucks in the field of raceway would also serve to help elucidate the functional working of the farm complex. Given the timeline and the nature of the project, the final design proposal was a diagrammatic visualization of the science behind crab farming, and the potential for crab farming in an eco-conscious manner. In future design development, the project would benefit from a revisualization of the raceway unit itself, perhaps using non-conventional greenhouse elements, or using conventional greenhouse elements constructed in an unconventional way. The project could be even stronger representationally if the greenhouse roofs began to assume the form of the sloped-meadow/sloped-wetland. The manipulation of the ground plane was such as powerful strategy that if these same formal techniques were employed at the level of the raceway roofscape, the project could become even stronger. The building's siting in relationship to the visitor's experience would also benefit from a more extensive investigation. Given the opportunity for future development, the immediate site plan should be rethought in terms of extending site walls into the terraced landscape and morphing to become site amenities (benches, etc.) for the user.

As a study for further investigation, the project would benefit from research regarding the actual size (particularly depth) of the constructed wetlands. The wetlands should be sized in such a manner that they can accommodate heavy runoff from the berms/raceways, and remediate the crab debris in a matter of days. Further investigation of the networking of these ponds would have to be investigated and scientifically engineered with positive drainage, day lighting, etc. This engineering was beyond the scope of the project at this time. Although the layout would have to be re-engineered for boat transport, the possibility of deploying crab farms in the soon-to-be flooded southern Dorchester could also be a valuable avenue for further research.

A FUTURE FOR BLUE CRAB FARMING

As the amount of cropland in Maryland has shrunk due to an explosion of development and the number of chickens raised has grown to 570 million, chicken manure has become a major environmental hazard threatening the entire region and its watershed. It's hard to believe that there is no legislation in Maryland to prevent these mountainous piles of chicken excrement from washing directly into the bay. As a result, this manure continues to find its way into the Chesapeake where it further degrades the local water quality and worsens the plight of the fishermen who ply its waters (fig. 72). Maryland therefore faces a unique conundrum. By allowing the chicken farmers (and suburban real estate developers) to pollute without restriction, the state tacitly allows the livelihood of the watermen to deteriorate. The poultry industry in Maryland is the state's most lucrative form of agriculture contributing more than $700 million anually to the Maryland economy and is also one of its largest employers, so it's very difficult to muster the political power necessary to curb the growing amount of pollution the industry introduces into the Bay each year. [76]

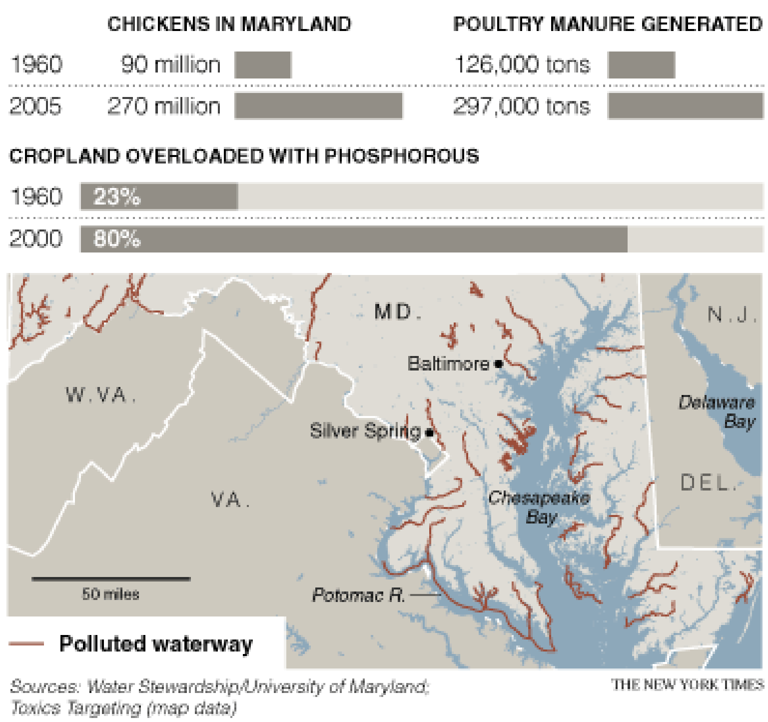


Figure 72 – Polluted Waterways in Maryland. Courtesy of the New York Times.

[76] Urbina, Ian. "In Maryland, Focus on Poultry Industry Pollution," New York Times, 11.28.2008.

The nation's growing demand for cheap chicken is outstripping the Maryland's ability to produce it while maintaining an environmental equilibrium, and state officials have started to realize that there are consequences to producing skinless, boneless chicken breast in such quantities that it sells from the farm and into the market at just over $2 per pound. There is virtually no other protein source with so little fat this cheap.[77] As the EPA works to implement President Obama's Executive Order on Chesapeake Bay Protection and Restoration, there will invariably be restrictions on chicken farming and pollution, especially because reducing pollution from agriculture is also about a tenth as costly as it is to achieve the same reductions from urban development. It is therefore the perfect time to envision new and sustainable farm initiatives that can begin to fill the gap in agricultural production that restrictions on chicken farming will invariably create.[78]

Given that crabs are an exceptionally resilient and hardy species, the costs associated with their farming should be relatively low compared to the market cost of a mature individual. A good comparison is that of the crab to the chicken. While the crab requires more space for growth and segregation, he requires none of the antibiotics that the chicken requires. What is more, since crabmeat goes for some $13.50 per pound, it could potentially rival the cost benefits of chicken farming (fig. 73).

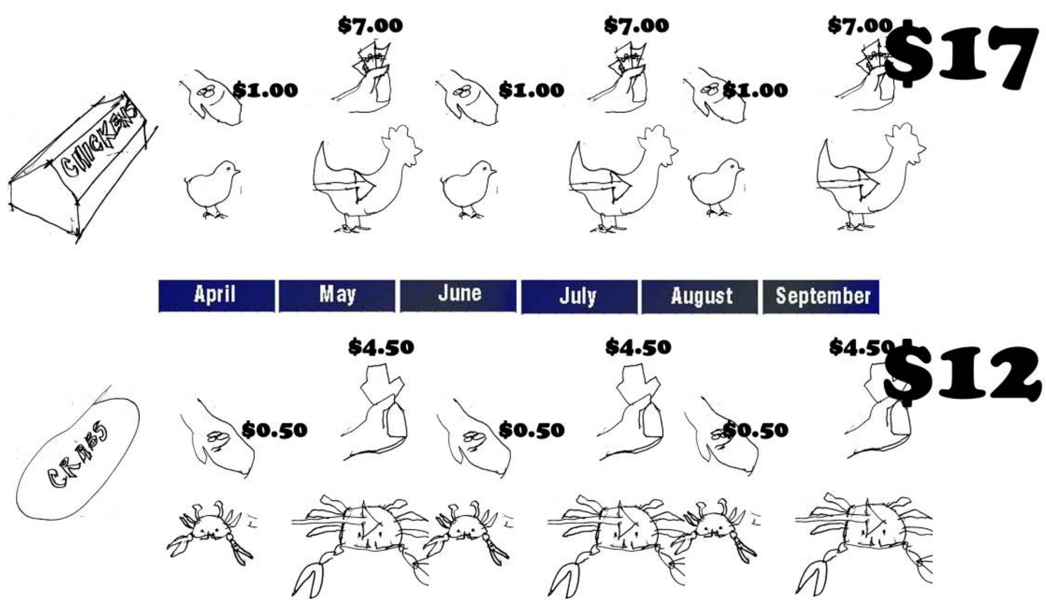


Figure 73 – Anticipated return on one crab versus anticipated return on one chicken. Author.

---

[77] Urbina, Ian. "In Maryland, Focus on Poultry Industry Pollution," New York Times, 11.28.2008
[78] http://www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/pr110409.pdf

It is almost poetic to think that crab farming could go on to replace the industry which has in part brought the crab to near extinction. It is also somewhat ironic to think that by eating crab raised on fenced land we could be saving him in open waters. And while crabmeat retails at a price far greater than chicken, it is reasonable to believe that we could make it a state objective to cut our chicken production in favor of a more expensive yet environmentally friendly foodstuff. Officials in Dorchester, Wicomico, Somerset, and Worcester Counties have voiced their interest in assisting and incentivize organic farming operations of this type within their counties. In summary, crab farming represents a win-win situation for Maryland and even for the nation at large. By curbing farm industries that pollute the Bay and replacing them with organic crab farming operations, we can remediate the water quality in the Chesapeake Bay, save the Chesapeake Bay blue crab from extinction, contribute real economic value to the state economy, and maybe even save the dying tradition of the Maryland waterman (fig. 74).

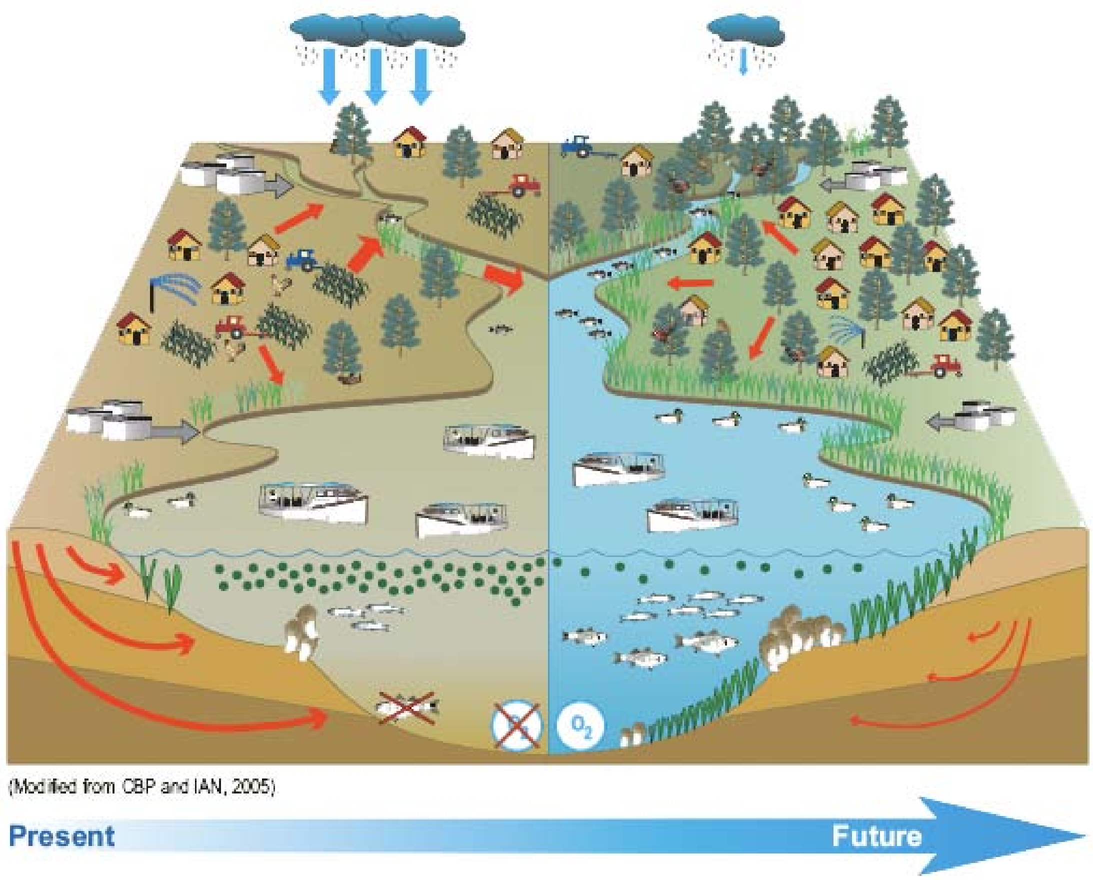


Figure 74– Future of the Bay. Online Illustration.

The glossary below comes from a variety of sources. Many of the entries have been imported wholesale from an excellent online resource, ChesapeakeBay.Net: http://www.chesapeakebay.net/glossary.aspx?menuitem=14875

Algae - Tiny, single-celled planktonic plants. Algae, or phytoplankton, are the primary producers of food and oxygen in the Bay food web.

Algae bloom - A dense population of algae fueled by excess nutrients. Algae blooms rob the Bay's aquatic life of sunlight and dissolved oxygen.

Anadromous - Fish that spend most of their lives in salt water but must migrate to freshwater tributaries to spawn. Sturgeon and shad are both anadromous fish.

Anaerobic - Not containing oxygen or not requiring oxygen.

Angler - Someone who fishes recreationally with a hook, line and rod.

Anoxia - A condition where no oxygen is present in the water. Also called a "dead zone."

Anthropogenic - Caused by humans.

Aquatic reef - A solid, three-dimensional ecological community made up of densely packed oysters or other artificial substances. Aquatic, or oyster, reefs provide vital habitat for finfish, crabs and other invertebrates.

Arthropod - A diverse group of invertebrates that have jointed legs and an exoskeleton, or external skeleton. Aquatic arthropods include horseshoe crabs and crustaceans like blue crabs and barnacles. Terrestrial arthropods include insects, scorpions and spiders.

Artificial reef - An underwater structure made of artificial substances (such as concrete or metal) that mimics oyster reefs and provides habitat for aquatic species that live on or around aquatic reefs.

Atmospheric deposition - When pollutants in the air fall onto the land or water. Pollution that falls with rain or snow is called wet deposition, and pollution that falls without precipitation is called dry deposition.

B

Backwater - A still body of water or a still portion of a larger body of water that is unaffected by the flow of the larger body of water. A small stagnant branch of a river would be considered a backwater.

Baseflow - The portion of river flow that comes from groundwater, rather than runoff.

Basin - An area of land that drains into a particular river, lake, bay or other body of water. Also called a watershed.

Bathymetry - The varying physical characteristics—including depth, contour and shape—of the bottom of the Bay and other bodies of water.

Bay jurisdictions - Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and the District of Columbia

Benthic - Bottom-dwelling. Benthic organisms spend at least part of their lives in, on or near the bottom of streams, rivers, lakes or the Bay. This group consists of plants and animals including worms, shellfish and bottom-feeding finfish

Best management practices (BMPs) - The most effective and practical ways to control pollutants and meet environmental quality goals. BMPs exist for forestry, agriculture, stormwater and many other sectors.

Bioaccumulation - When chemical contaminants accumulate in the tissues of a living animal, typically increasing in concentration as you move up the food chain. For example, a small fish eats contaminated algae, then a bigger fish eats many contaminated small fish, and a human eats the bigger, now-contaminated fish.

Biological nutrient removal (BNR) - Technology that removes nitrogen and phosphorus during wastewater treatment.

Biomass - The amount of a living species, expressed as a concentration or weight per unit area.

Bioretention site - Also called a rain garden; an innovative method of stormwater management that retains rainwater and uses plants and layers of soil, sand and mulch to reduce the amount of nutrients and other pollutants that enter local waterways.

Biota - The flora and fauna of a region.

Bivalve - A mollusk with two shells that are connected by a hinge. Clams and oysters are bivalves.

Bog - A type of wetland that has poorly drained acidic peat-soil dominated by sedges and sphagnum moss.

Brackish - A combination of fresh and salt water. Most of the water in the Bay is brackish.

C

Carapace - A hard shell covering the back of an animal, such as a crab or turtle.

Clutch - A group of eggs laid together at one time.

Coastal plain - The level land downstream of the piedmont and fall line, where soils are generally finer and fertile and rivers are influenced by the tide.

Commensal - A two-species association in which there is a positive effect on one species and neither a positive nor a negative effect on the other.

Crustaceans - Aquatic arthropods (invertebrates) that have gills and jointed legs. Crabs, shrimps, barnacles, amphipods and isopods are all crustaceans.

D

Delmarva Peninsula - The land separating Chesapeake Bay from the Atlantic Ocean. The Delmarva Peninsula is made up of parts of three states: Deleware (Del-), Maryland (-mar-) and Virginia (-va).

Denitrification - The process by which nitrates are reduced to gaseous nitrogen.

Detrivore - Any organism that gets most of its nutrients from the detritus in an ecosystem.

Dissolved inorganic nitrogen (DIN) - Nitrogen that is readily usable by plants.

Dissolved oxygen (DO) - The amount of oxygen that is present in the water. It is measured in units of milligrams per liter (mg/L), or the milligrams of oxygen dissolved in a liter of water. Just like humans, all of the Bay's living creatures need oxygen to survive.

Diurnal - An animal that is active during daylight.

E

Easement - A limited right to use a part of land owned by another person or organization.

Ebb tide - A falling tide.

Effluent - Discharge of liquid waste from a wastewater treatment facility, factory or industry to a local waterbody.

Endemic species - A species that is restricted in its distribution to a particular locality or region.

Estuary - A partially enclosed body of water where fresh water from rivers and streams mixes with salt water from the ocean. It is an area of transition from land to sea.

Euryhaline - Used to describe aquatic organisms that tolerate a wide range of salinities.

Eutrophic - An aquatic system with high nutrient concentrations, which fuels algal growth. This algae eventually dies and decomposes in a process that reduces the amount of dissolved oxygen in the water.

Eutrophication - The process of excess nutrients accelerating the growth of algae, ultimately depleting the water of dissolved oxygen.

Exoskeleton - Hard outer shell that provides an invertebrate with support and protection. Blue crabs and other crustaceans have exoskeletons.

F

Fall line - The boundary between the Piedmont Plateau and the Coastal Plain, ranging from 15 to 90 miles west of the Bay. Waterfalls and rapids clearly mark this line, which is close to Interstate 195.

Fecundity - The number of eggs produced per female during a spawning season.

Filter feeder - An organism that feeds by pumping large volumes of water through its gills or mouth and filters out plankton and other particles. Oysters and menhaden are both filter feeders.

Flood tide - A rising tide.

Freshet - An increase of water flow into the Bay during late winter or spring due to increased precipitation and snow melt in the watershed.

G

Groundwater - Water that is stored underground in cracks and spaces in rock and soil.

H

Herbaceous - Plants without woody stems.

Holocene Extinction Event - The widespread, ongoing mass extinction of species during the modern Holocene epoch, which began some 11,700 years ago.

Hypoxia - A condition in which oxygen levels in water are very low.

I

Impervious - A surface or area that is hardened and does not allow water to pass through. Roads, rooftops, driveways, sidewalks, pools, patios and parking lots are all impervious surfaces.

Infauna - Animals and bacteria of any size that live in bottom sediments. Worms and clams are considered infauna. They form their own community structures within bottom sediments, connected to the water by tubes and tunnels.

Intertidal - The area of shoreline between the high tide and low tide marks.

Introduced species - A species that has been intentionally or inadvertently brought into a region or area. Also called an exotic or non-native species.

Invertebrate - An animal that lacks a backbone. Aquatic invertebrates include squids, shrimps, crabs, mollusks and sea stars.

J

K

Keystone species - A species that affects many other organisms in an ecosystem. If a keystone species substantially increases or decreases in population, it may have a cascading effect on the rest of the ecosystem.

L

Larva - The tiny, newly hatched stage of many insects and aquatic animals.

Light attenuation - Reduction in the amount of light that can penetrate through the water, usually caused by excess suspended sediment or algae blooms.

Littoral zone - The intertidal area of the shoreline, between the high tide and low tide marks.

M

Macroinvertebrates - Large, generally soft-bodied organisms that lack backbones.

Mainstem - The region of Chesapeake Bay extending from the Susquehanna River to the mouth of the Bay, not including the tributaries.

Marsh - A border habitat that connects shorelines to forests and wetlands. Marshes are found in fresh, brackish and salt water areas.

Maxilliped - One of three pairs of claw-like structures located near the mouth on the heads of crustaceans.

Megalops - A second larval form of the blue crab.

Mesohaline - Moderately salty waters with salinities that range from 5 to 18 parts per thousand (ppt).

Mesotrophic - An aquatic system that is somewhere between eutrophic (nutrient enriched) and oligotrophic (nutrient poor).

Molt - Arthropods routinely cast off (slough, shed) their exterior exoskeleton in order to grow.

Mollusk - A phylum of invertebrates that includes bivalves (clams, oysters and mussels), gastropods (snails) and cephalopods (squids).

N

Nearshore - The relatively shallow waters between the shoreline and deeper, open waters.

Nekton - Organisms that are able to swim through the water column and move against currents. Nekton include fish, blue crabs, whales and rays.

Nitrification - The process through which ammonia is oxidized into nitric acid or another type of nitrate or nitrite. Biological nitrification is a key step in nitrogen removal in wastewater treatment.

Nocturnal - An animal that is only active at night.

Nutrient trading - The transfer of nutrient reduction credits, specifically for nitrogen and phosphorus.

Nutrients - Chemicals that plants and animals need to grow and survive. However, excess amounts of nutrients can be harmful to aquatic environments. Elevated levels of nitrogen and phosphorus, two types of nutrients, are the main cause of the Bay's poor water quality and loss of aquatic habitats.

O

Oligohaline - Brackish waters with low salinities that range from 0.5 to 5 parts per thousand (ppt).

Oligotrophic - A water body or habitat with low concentrations of nutrients.

Overwinter - To remain alive or viable and/or hibernate through the winter.

P

Pelagic - The open ocean, excluding the ocean bottom and shore.

Photic zone - The layer of water that sunlight is able to penetrate through and reach plants growing underwater.

Photosynthesis - The process by which plants convert carbon dioxide and water into carbohydrates and oxygen. The carbohydrates can then be used as energy by the plant or other consuming organisms. This process is also referred to as "primary production."

Phytoplankton - Tiny, single-celled planktonic plants. Also called algae. Phytoplankton are the primary producers of food and oxygen in the Bay food web.

Polyhaline - Salty waters with salinities that range from 18 to 30 parts per thousand (ppt).

Primary producers - Organisms, such as algae, that convert solar energy to organic substances through chlorophyll. Primary producers serve as a food source for higher organisms.

Pycnocline - The zone or boundary where the fresher water layer on the surface meets the saltier water layer below. The pycnocline can be a physical barrier that prevents mixing or exchange between the two layers.

Q

R

Riparian - The area of land next to a body of water. Riparian areas form the transition between aquatic and land environments.

Riparian forest buffers - Trees and/or other vegetation located along the edge of streams, rivers and other waterways that filter pollution, prevent erosion and provide wildlife habitat.

S

Salinity regime - Water distinguished by its salinity and tidal influence. The major salinity regimes are tidal fresh, oligohaline (brackish), mesohaline (moderately salty) and polyhaline (salty).

Salt marsh - Wetlands that are located in salt water areas and are dominated by cordgrass, also called *Spartina*. Salt marshes are one of the most productive plant communities on earth.

SAV - Stands for submerged aquatic vegetation, the technical term for underwater bay grasses. SAV help improve water quality and provide important food and habitat for fish, shellfish, invertebrates and waterfowl.

Sediment - Loose particles of clay, silt and sand. Excess suspended sediment from erosion is one of the largest contributors to the Bay's impaired water quality.

Shellfish - Aquatic animals, such as clams, crabs, oysters and shrimps, that have a shell or shell-like external skeleton.

Spawn - To release eggs and/or sperm into the water.

Species - A group of organisms made up of similar individuals that are capable of breeding with one another.

Stormwater - Any precipitation in an urban or suburban area that does not evaporate or soak into the ground, but instead pools and travels downhill. Stormwater is also referred to as urban stormwater, runoff and polluted runoff. Increased development across the Bay watershed has made stormwater runoff the fastest growing source of pollution to the Bay and its rivers.

Stratification - The division of warmer, lighter fresh water over a layer of saltier and denser water in the Bay. Stratification of the two layers varies within any season depending on rainfall.

Stream bank erosion - Loss of sediment along a stream bank as a result of increased runoff from nearby development. Stream bank erosion degrades stream habitats for wildlife and increases suspended sediments in the water.

Subtidal - The area of shoreline that is always submerged, even at the lowest tide.

Suspended sediments - Tiny particles of clay and silt that become suspended in the water, reducing water clarity and the amount of sunlight that can reach underwater bay grasses. Excess suspended sediment is one of the largest contributors to the Bay's impaired water quality.

Swamp - A type of wetland dominated by woody vegetation or trees.

T

Tidal mud flat - The unvegetated area of shore that is exposed during low tide.

Tributary - Streams and rivers that eventually flow into a larger water body or the Bay. For example, the James River is a tributary of the Chesapeake Bay.

Trophic level - Each step along a food chain; an organism's feeding level.

U, V

W

Wastewater - Water that has been used in homes, industries and businesses that is not for reuse unless treated by a wastewater facility.

Watershed - An area of land that drains into a particular river, lake, bay or other body of water. We all live in a watershed: some are large (like the Chesapeake), while others are small (like your local stream or creek).

Wetland - A transitional zone between land and water that is periodically saturated or flooded. Marshes, swamps and bogs are all types of wetlands.

Y

Z

Zoea - A tiny, semi-transparent larval blue crab.

Campbell, Craig; Ogden, Michael. Constructed Wetlands in the Sustainable Lanscape. New York: Wiley, 1999.

Corner, James. Recovering Landscape. New York: Princeton Architectural Press, 1999.

Dramstad, Wenche; Oldson, James; Foreman, Richard T.T. Landscape Ecology Principles in Landscape Architecture and Land-Use Planning. Washington: Island Press, 1996.

Farenthold, David. "East Coast May Feel Rise in Seal Levels the Most," Washington Post, June 8, 2009.

Forman, Richard T.T. Land Mosaics: The Ecology of Landscapes and Regions. Cambridge: Cambridge University Press, 1995.

Kennedy, Victor and Cronin, Eguene. The Blue Crab: Callinectes Sapidus. College Park, Maryland: Maryland Sea Grant College Publications, 2007.

Kliman, Todd. "Crab Imperialist," Washington City Paper, July 15–21, 2005.

McLarney, William. *Freshwater Aquaculture: A Handbook for Small Scale Fish Culture in North America*

Shafer, Craig L. Nature Reserves: Island Theory and Conservation Practice. Washington: Smithsonian Institution Press, 1990.

S.L. Pimm, G.J. Russell, J.L. Gittleman and T.M. Brooks, *The Future of Biodiversity*, Science 269: 347-350 (1995)

Urbina, Ian. "In Maryland, Focus on Poultry Industry Pollution," New York Times, November 28, 2008.

Waldheim, Charles (editor). The Landscape Urbanism Reader. New York: Princeton Architectural Press, 2006.

Williams, Ernest. Personal interview. April 8, 2009.

Zohar, Jonathan. Personal interview. April 8, 2009.

Zmora, Odi. Personal interview. April 8, 2009.

www.cbf.org/badwaters/

www.washingtonpost.com/wp-srv/metro/interactives/failingthechesapeake/