SYNTROPHIC WATERS

A Vision for (Co-)Productive Marine Conservancy

by

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I hereby declare that I am the sole author of this thesis.

This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

ABSTRACT

The twentieth century witnessed a dietary shift in Japan, which resulted in greater consumption of exotic seafood species that occupy high trophic levels. This, along with the industrialisation of commercial fisheries and the subsequent global popularisation of Japanese cuisine in the post-war era have all contributed to the current ecological crisis in all of the world's oceans. The rapid depletion of marine biomass and large-scale destruction of ocean ecosystems have led to an intensifying marine metabolic rift[1] that threatens not only the survival of marine species, but also the livelihoods of communities still dependent upon their small-scale fisheries industries.

It is clear that a new fisheries model is needed. Rather than pitting the preservation of ecosystems and the provisioning of affluent markets against one another, this thesis envisions a hybrid model that combines conservation efforts with more sustainable production practices. It calls for a bottom-up approach that prioritises the establishment and maintenance of suitable habitats for fish populations to thrive. This

1. Rebecca Clausen and Brett Clark, "The Metabolic Rift and Marine Ecology," *Organization & Environment* 19, no. 4 (2005): 425.

model of syntrophic production would transform the fisheries worker from a mere extraction expert to a marine steward.

The Japanese town of Oma, in the northern prefecture of Aomori, is the testing ground for this new fisheries model. Renowned for its annual landings of Bluefin tuna, this remote, northern community is especially vulnerable to the impending commercial collapse of the species. Through the establishment of a "productive marine refuge", the thesis aims to provide alternative revenue routes for the town's fisheries workers while simultaneously allowing for the rehabilitation of the region's marine ecosystem. The existing fishing port and associated shoreline are transformed into an intensive working landscape that supports the complex trophic relationships in the marine environment. At the same time, the new landscape will provide an opportunity for the general public to engage with the production processes that support its consumption habits.

To my supervisor, Jane Hutton, and committee advisor, Terri Boake, thank you for your patience and guidance throughout my thesis journey. Your unwavering enthusiasm and gentle encouragement have been an amazing inspiration for my work.

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Finally, I would like to thank my family and friends. Without your love and support, this thesis would not have been possible.

For the foodies,

for the workers,

and most importantly,

for the fish.

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Introduction

Figure 1.1. - Frozen tuna unloaded from a refrigerated boat with a crane at Shimizu Port, Japan. [Nagasawa, 2015]

1.1 *Introduction*

Whether served raw in the form of sushi and sashimi or grilled in preparation of takoyaki and ikameshi, seafood plays a critical role in much of Japanese cuisine. But while the seafood culture of Japan is a source of national pride, it is not without great ecological cost. Having maximized, and even exceeded, the productive capacity of its own waters decades ago, the country has ventured into distant regions far beyond its own maritime borders in its quest for the ocean's bounty.

The oceans, once assumed to be an inexhaustible food source, are now facing a deep crisis. Decades of industrialised fishing activities and ever-increasing appetites for seafood have decimated the populations of many marine species and wreaked havoc upon multiple ocean ecosystems[1]. In a 2016 report titled *The State of World Fisheries and Aquaculture*, the Food and Agriculture Organization of the United Nations claimed that nearly 90% of major fisheries have reached or exceeded their capacity to cope with human exploitation[2]. Meanwhile, the global consumption of marine food products reaches new record highs each year. This increase arises partly as a result of the international popularisation of regional cuisines in affluent markets, but also as agricultural lands vital to the production of livestock are lost due to climate change and urban development needs[3], leading to greater dependency on the ocean as a stable food source. These trends only serve to create additional pressures on already stressed ocean ecosystems.

Of the many species of fish consumed by the Japanese, no other fish is more entangled with the myriads of ecological issues associated with modern fisheries than the giant Bluefin tuna (*Thunnus thynnus/Thunnus orientalis/Thunnus macoyii*). From overfishing to waste accumulation, the Bluefin tuna industry is mired in scandal and controversy. This species provide a perfect lens of investigation to illustrate humankind's increasingly problematic relationship to the oceans. More importantly, a careful examination of the relationship between Japan and Bluefin tuna would reveal that cultural practices, including dietary habits, are not fixed traditions, but rather, they undergo constant evolution as a result of both internal and external influences.

Yet, the many social benefits offered by the oceans cannot be ignored. The fisheries industry provide employment for twelve percent of the global population[4] not only through jobs in the primary fisheries and aquaculture sector, but also in complementary value-added industries such as food services and trans-regional logistics. It is also a key resource for achieving global food security, particularly in developing countries. Thus, in the face of growing consumption demand and declining marine biomass, the careful management of fisheries and marine ecosystems is incredibly vital in the longterm to both economic and ecological development.

Marine conservationists and fisheries workers have yet to widely adopt any common solutions that can accommodate both environmental rehabilitation and economic development agendas. Driven by the capitalist pursuit of profits, large scale fishing operations continue their rapid depletion of marine biomass, despite such practices being at odds with the urgent need for rehabilitation[5]. For many coastal communities that are reliant upon smaller scale fishing practices as local economic drivers, it is becoming increasingly difficult to compete for access to remaining fish stocks.

What will become incredibly vital in the oncoming decades is the implementation of marine rehabilitation programmes and sustainability strategies that also provide economic returns to the communities that depend on the oceans' resources for regional development. The establishment of productive marine refuges—sites in which human fishing activities work symbiotically with natural ecological processes—offers one solution to the current ocean crisis. These sites would allow the co-inhabitation of human and marine species, transforming fisheries from an exercise in extraction to one of stewardship. While providing viable means of livelihood for coastal inhabitants, they will also support the ecosystem recovery efforts.

The first chapter of this book traces the historical development of modern industrial fisheries, particularly that of the Bluefin tuna. It begins by following the rise of Bluefin tuna consumption in post-war Japan and the transformation of Bluefin tuna fishing from an occasional recreational activity to a fully industrialised industry. The global scope of this industry has resulted in unlikely connections between distant geographies, which is uncovered through an examination of the convoluted network of operation behind this regional delicacy. This network also reveals the widening metabolic rift between humans and the seas, a problem first conceptualised by marine sociologists Rebecca Clausen and Brett Clark. Using the Marxist notion of the metabolic rift as an analytical tool to understand the imbalanced transfer of materials and energies within the modern fisheries industry, this chapter will critically examine the larger socio-ecological issues impacted by existing marine-based food production practices and the effects of human activities on complex marine ecosystems.

The second chapter takes a closer look at how the fisheries industry and marine conservationists can begin working together to tackle the metabolic rift. Given the bleak outlook for many marine species, humans must reconfigure their relationships with the oceans if we are to continue to rely upon it as both a food source and an economic development tool for the foreseeable future. After all, the culture of seafood can only continue if there is something left in the sea to be harvested and consumed. The vulnerability of many coastal communities to ecosystem collapse and impending commercial extinction means it is absolutely vital that a new approaches to marine-based food production are needed — ones that are that are both economically and ecologically sustainable. The chapter explores some emerging marine practices that take on a more holistic approach to coastal development and ocean conservancy. It compiles various experimental marine rehabilitation and seafood production strategies from around the world into a best practices guide for the establishment of a productive marine refuge (PMR). The chapter also makes a case for why production and conservation activities ought to go hand in hand together in order to begin mending the aforementioned metabolic rift.

The third chapter returns to Japan to shine a spotlight on the remote, coastal community of Oma. The town is heavily dependent on its fisheries industry and renowned for its Bluefin tuna landings each winter. Despite being situated in one of the poorest regions of the country, its prime, northerly location and commitment to small-scale fishing means it is perfectly positioned to take full advantage of the astronomical prices that Bluefin tuna can fetch at wholesale market auctions in faraway urban centres such as Tokyo and Osaka. Nonetheless, faced with the possibility of the commercial extinction of Bluefin tuna, the town must prepare itself for a transformation of its fisheries sector. The Productive Marine Refuge of Oma is a speculative proposal that treats the coastal waters of Oma as an experimental site for the establishment of a new economic and ecological vision—one in which fisheries workers are not only producers in service of the consumption market, but are also engaged as caretakers and stewards of the waters upon which they rely. The proposal comprises of three major components: a learning market centre, a kelp and oyster farm, and a coastal marine park. Together, they address the three urgent issues faced by stakeholders (both human and wild species) associated with the modern seafood industries: rising demand for the consumption of high value marine food products, dwindling biomass leading to ecosystem collapse and economic vulnerability in the face industrial pressures.

This goal of this thesis is not to provide a singular solution to the marine biomass crisis, but rather to highlight a variety of holistic strategies that can allow our production activities and consumption habits to evolve into more sustainable practices. The aim is to reposition our role in natural systems and explore how we may reconfigure our relationship with the oceans for the long term benefit of both human and ecological development. Through a careful examination of the current marine ecological challenge and a reimagining of how humans may impact marine landscapes, this book hopes to opening up further dialogue between consumers, conservationists and producers.

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The Marine Biomass Crisis

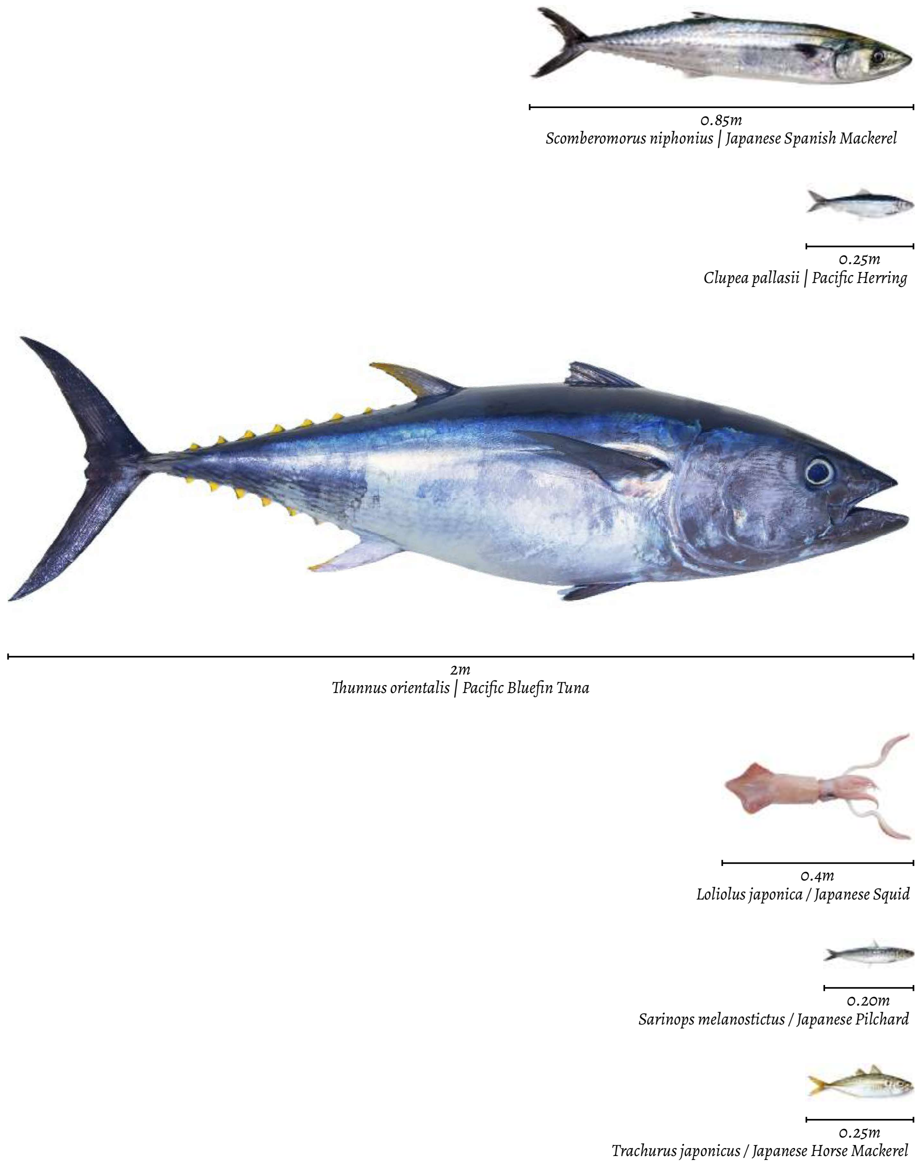


Figure 2.1 - A comparison of Bluefin tuna and some of its prey

2.1 The Decline of Bluefin Tuna

Sushi, a dish that consists of a minimally prepared slice of seafood atop a lightly seasoned bed of rice, is a quintessential component of Japanese cuisine. Over the past century, it has exploded in popularity not only in Japan itself, but also much further abroad, in countries on the opposite side of the world. Amongst the many marine delicacies that diners can sample at sushi establishments, few inspire as much excitement as *otoro* - the fatty underbelly of the Bluefin tuna. Often misunderstood as a traditional feature of sushi dining, the consumption of Bluefin tuna is actually a modern practice that only began in the post-war era. As Japan emerged out of the shadows of the second world war, the country shifted away from its historically plant-based diet of subsistence and began to adopt more animal-derived proteins in their diet. This dietary transformation came about partly as a result of Western influences on the Japanese diet, but is also due in part to the growing affluence within the country. The consumption of Bluefin tuna soon became a status symbol in the post-war era, and newly industrialised commercial fisheries clambered to keep up with the growing demand. The effects of this extraction and consumption has been catastrophic for the oceans.

The Bluefin tuna is an awe-inspiring animal that counts itself amongst the top predators of the sea (Figure 2.1). It can be found throughout many parts of the world's oceans. Its three subspecies—*thunnus maccoyii*, *thunnus orientalis* and *thunnus thynnus*—are identified according to their geographic range (Figure 2.2). Although the average specimen is typically two metres long, the species can grow

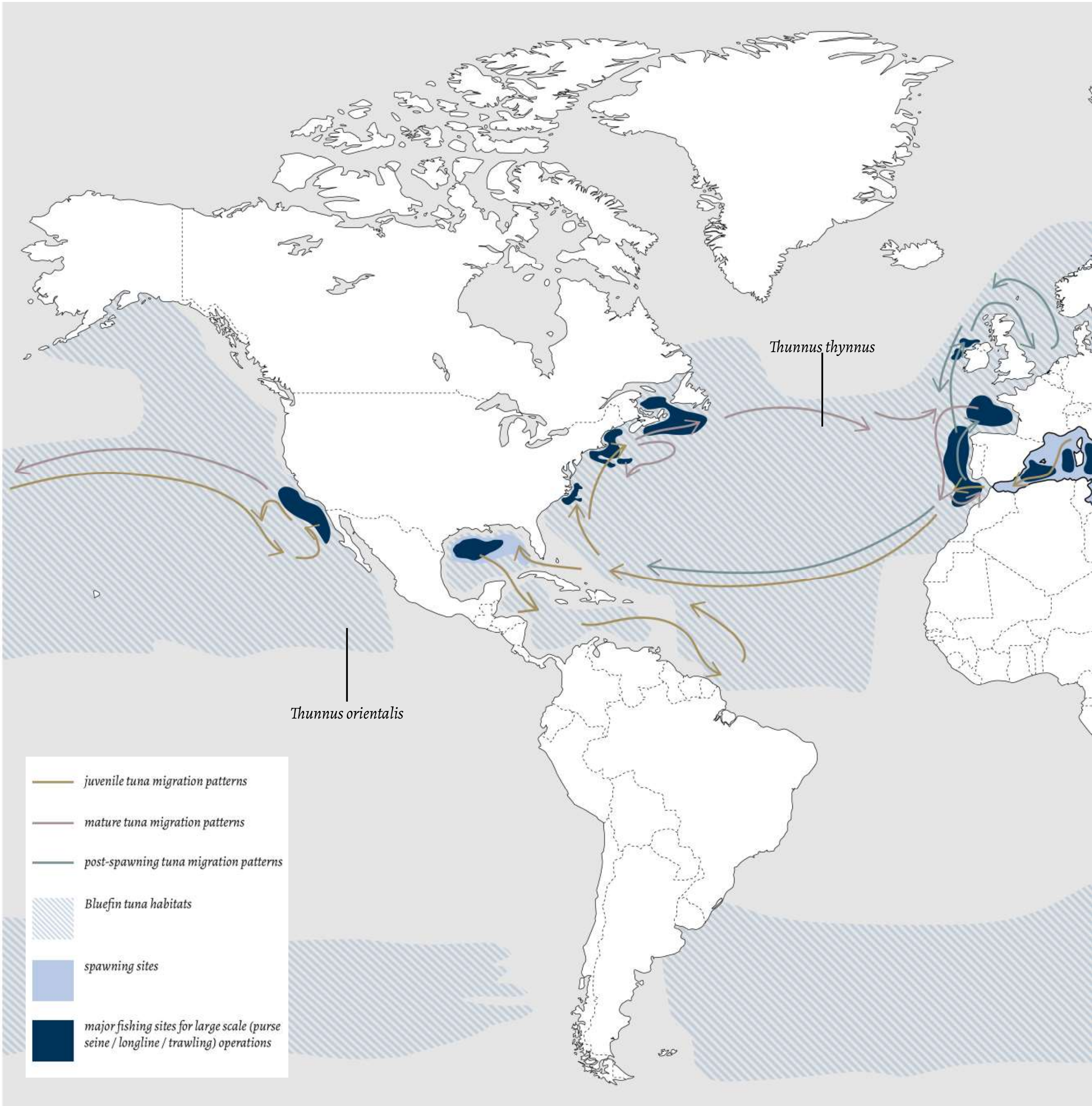
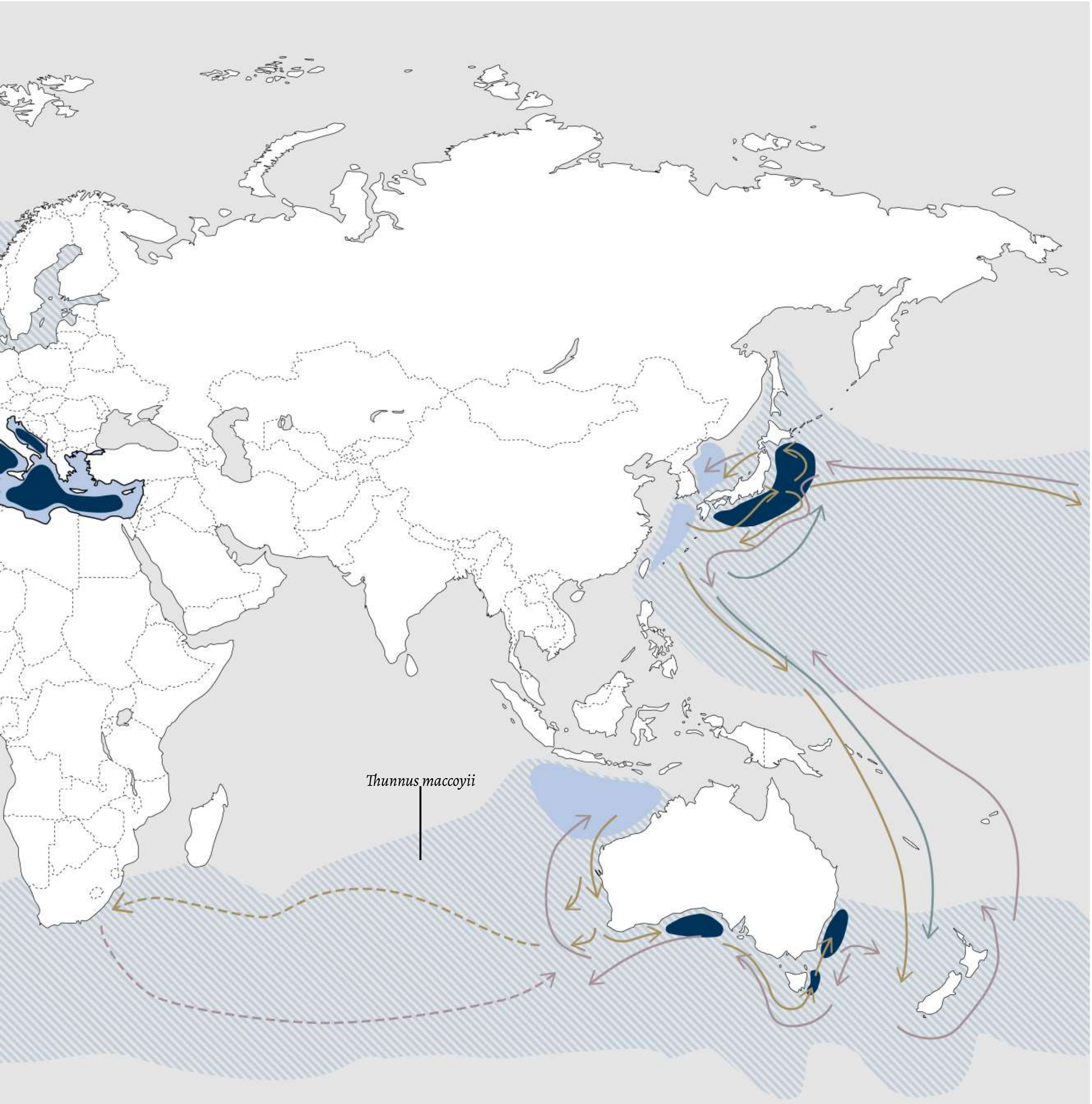


Figure 2.2 - A map of the geographic range for Bluefin tuna and key habitat regions



Thunnus maccoyii

up to three metres in length and four hundred fifty kilograms in weight. The natural endothermy of Bluefin tunas allows them to survive in a much greater range of water temperatures and swim with great speed across long distances[1]. However, these abilities also require them to consume much more food in order to support their higher metabolism. As a result, they are highly migratory apex predators that swim for thousands of kilometres between opposite sides of the ocean to forage from a variety of cephalopods, crustaceans and fish, and return to their spawning grounds several times throughout their life cycles.

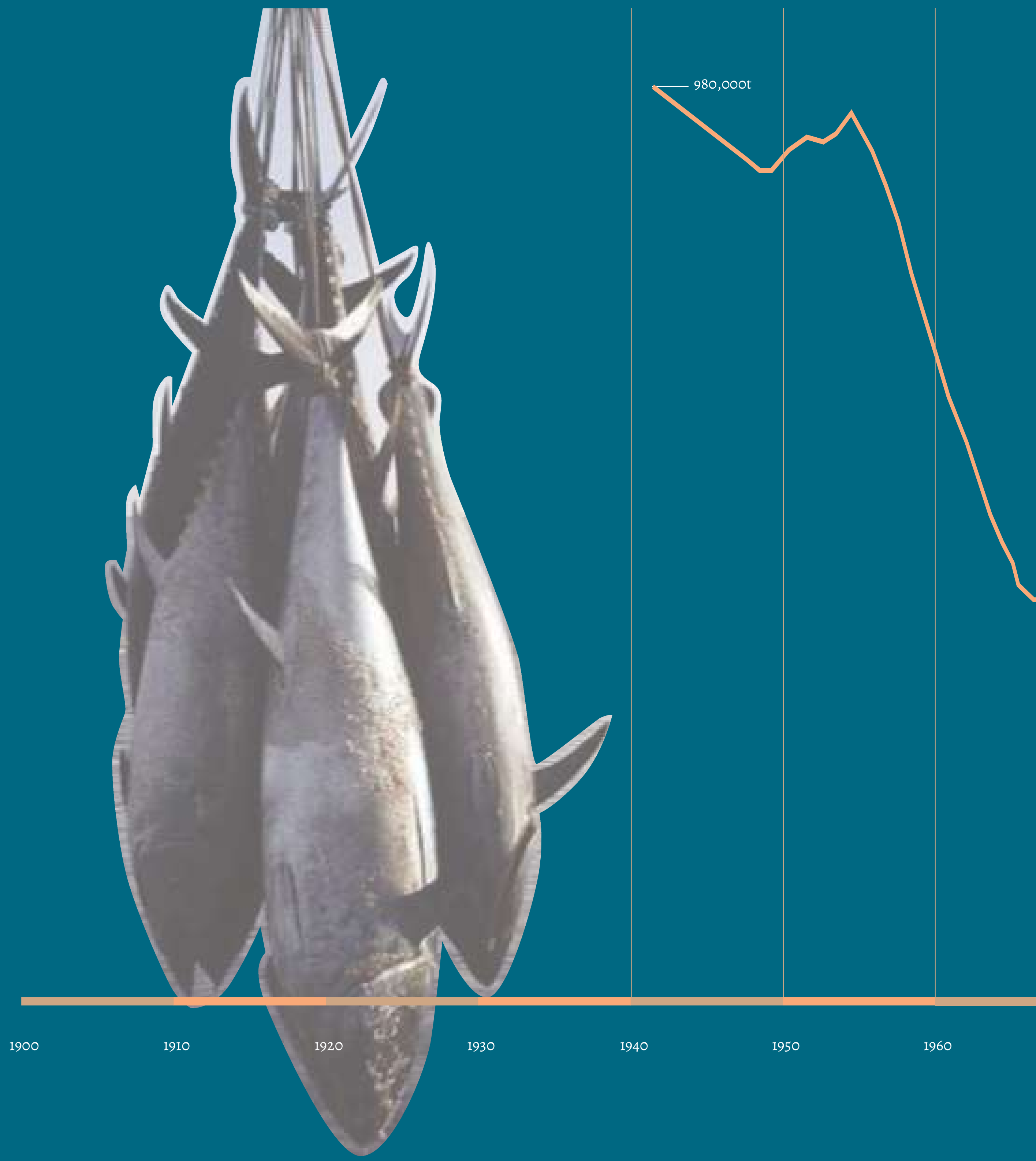
Bluefin tunas command exorbitant prices at the market, and the allure of lucrative profits have led to the establishment of a complex network of production distributed throughout the world. Unceasing demand for the fish has brought incredible wealth to backwater towns that are situated faraway from the consciousness of diners in bustling urban markets[2]. Bluefin tuna fishing operations, largely in service of the Japanese market who consumes 80% of the global catch[3], can be found everywhere from the Mediterranean Sea to the the Great Australian Bight. The adoption of geolocation equipment and large-scale extraction techniques such as purse-seining has allowed the fisheries industry to maximize its efficiency while reducing risk for vessels operating at sea.

Figure 2.3 - Ken Fraser posing with the record-breaking 1,496-pound Bluefin tuna that he caught off the coast of Nova Scotia in 1979. [Ellis, 2008]

Commercial extraction of Bluefin tuna only began in earnest in the 1950s. Prior to this period, Bluefin tunas were primarily sought out only by recreational fishers who were captivated by their incredible size. Once a commemorative photo had been taken (Figure 2.3), the catch would be discarded. Occasionally, the fish would be ground up and used for cat food when they were caught up by accident in the nets of herring or mackerel fishermen, but otherwise, it served little commercial purpose especially with regard to human consumption[4]. Even the Japanese, whose cuisine is now synonymous with the consumption of all things marine, had no interest in the fish.

Although the modern Japanese diet is beholden to the historical traditions that matured during the Tokugawa period (1603 - 1868), it is also shaped heavily by the Western influences which have been wholeheartedly embraced by the country in the post-war era. Prior to the twentieth century, the country largely followed a plant-based diet of subsistence[5]. A seventh century imperial decree, in accordance with Buddhist doctrine, had prohibited the consumption of all animals save fish and birds[6]. This prohibition was retained in one form or another throughout the country's various political upheavals, even well into the Tokugawa period. The consumption of meat was a rare privilege that only the nobility could afford.

Furthermore, Japan is a country composed of many heavily forested, mountainous islands. With the exception of Hokkaido, there are few pastures suitable for animal breeding. What little arable land that remained was used mostly for food crop cultivation. The ban on meat, coupled with the the abundance of water resources in contrast to its limited terrestrial resources resulted in a regional gastronomic tradition characterized by its "aquatic omnivory"[7]. Nonetheless, the Japanese have historically shunned the consumption of Bluefin tuna. They found the fish's meat-like flavour unpleasant. Traditional Japanese fisheries have comprised mostly of freshwater species and a handful of smaller, coastal marine species such as sardines, squids, herrings and mackerels[8]. Even once the restriction on meat was lifted and



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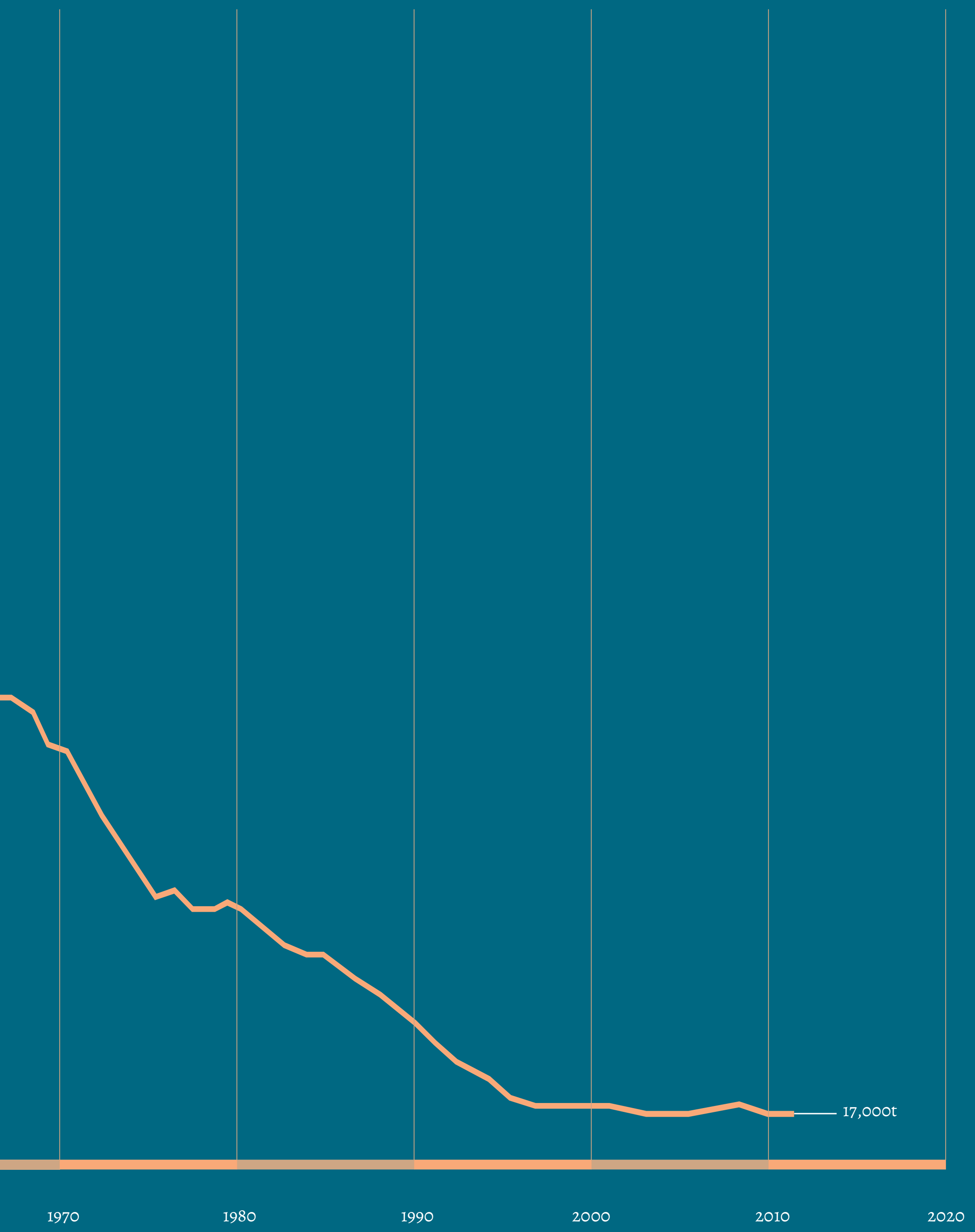

Figure 2.4 - Spawning stock biomass decline for the southern Bluefin tuna

Japan re-opened itself to Western trade during the Meiji period of the late nineteenth century, meat-based proteins still retained some of their social taboo and were not very widely adopted into the common diet. When meat was consumed, it was usually in relatively small quantities in a Western-style restaurant setting[9]. Maguro, Bluefin tuna, did finally gain some popularity as a sushi topping around that time, but it was akami, the leaner, less oily meat of the red inner muscles that diners preferred, rather than otoro and chutoro which are so esteemed and omnipresent today[10].

At the same time, changes were being made to the way in which sushi would be prepared. Though the sushi that most diners would recognize today is typified by a slice of raw fish with lightly seasoned rice, this style of sushi, *edomae nigirizushi*, did not emerge until the 19th century. Until significant advancements were made to transportation and preservation technology, sushi was a dish that consisted of fish fermented in a mixture of salt and cooked rice. Called *narezushi*, this dish relied on naturally produced bacterial lactic acid to extend the shelf life of harvested fish for up to a year[11]. Although the practice was carried out throughout most regions in Japan, it was most common in inland regions where access to fresh marine food sources were limited.

It was not until the American occupation following the Second World War that the Japanese truly began acquiring a taste for larger quantities of higher-fat proteins and adopted Western dietary habits as part of their regional cuisine[12]. Thanks in part to the Western style lunches distributed by American forces to Japanese schoolchildren, the country gradually grew accustomed to an increased consumption of animal-derived proteins and fats. This coincided with a massive economic boom in Japan, allow consumers greater access to new foodstuffs, particularly more expensive cuts of meat. With its growing economy, the country began shifting en masse from its traditional diet of subsistence to a modern diet of affluence[13]. Enjoyment came to be expected from the everyday consumption of food and the country gradually developed an affection for Bluefin tuna.

Unfortunately, the intensity with which commercial fisheries have extracted Bluefin tunas in the past half a century have decimated the species, so much so that their long term existence is now at risk. *Thunnus maccoyii*, the southern stock, has seen its spawning stock biomass plummet from 980,000t before commercial exploitation began in the 1950s to less than 20,000t in the 21st century (Figure 2.4)[14]. Similarly devastating declines have been observed for *Thunnus orientalis*[15] and *Thunnus thynnus*[16] as well. Fishing fleets have noted the increased difficulty of finding suitable fishing waters for Bluefin tuna harvests in recent decades[17]. The technologies adopted by fishing vessels in the post-war era, which made it easier to track down schools of Bluefin tunas and extract them en masse, are no longer enough to ensure a stable supply to the market. In fact, since the early 2000's, scientists have been warning of the impending commercial extinction of Bluefin tunas[18].

2.2 The Marine Metabolic Rift

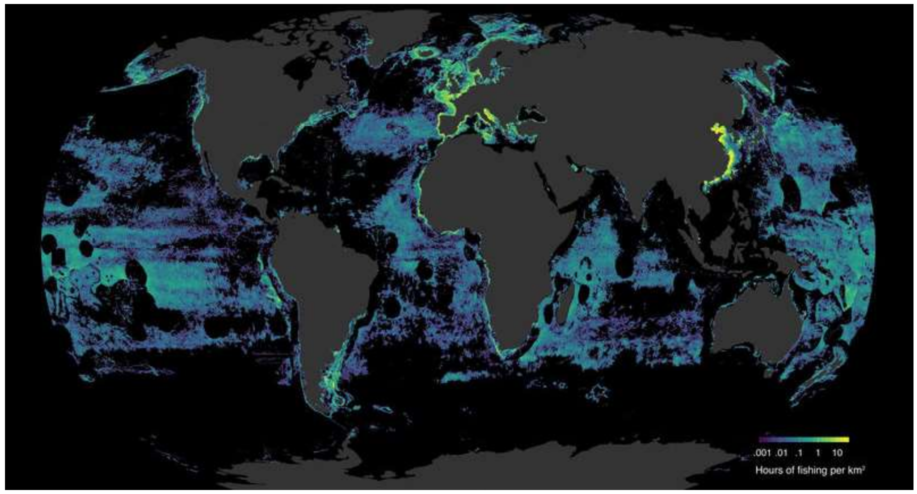

Figure 2.5 - Global Fisheries Acitivies in 2016 [Global Fish Watch, 2016]

The negative impacts of industrialised fisheries activities are not isolated to Bluefin tuna fisheries alone. As fish populations decline in near-shore waters, fishing vessels have had to venture farther out onto the high seas in an attempt to seek out still-abundant fishing waters. A 2016 map from Global Fish Watch (Figure 2.5) shows that while the highest intensity of fishing activities still occur in the waters that are nearest to shore, little of the earth's oceans have been left unexploited by fishing vessels. The expansion of the industry's geographic footprint is evidence of increasing decline in marine ecosystems[19].

One of the most significant consequences of this growing fisheries footprint is the widening of the marine metabolic rift, a term developed by environmental sociologists Rebecca Clausen and Brett Clark to describe the degradation of marine

Figure 2.6 - Ultra low temperature storage warehouses belonging to wholesale seafood traders at the fishing port of Shimizu, Japan [Asahi Shimbun, 2015]

fisheries caused by modern industrialised fishing and its expansive, transregional scope[20]. It criticizes the imbalanced exchange of materials and energies within the present fisheries production system. Organic materials necessary for the growth and survival of marine species are removed from ocean environments and deposited as waste on land, thereby disrupting the natural metabolism of ocean ecosystems. Modern industrialzed fisheries are able to extract fish in high volume from every corner of the world's oceans, gathering and reconcentrating these catches in major urban centres as seafood for consumption. A Japanese sushi restaurant can offer diners *otoro* from a Bluefin tuna caught off the coast of Spain or Canada only the day before. But the removal of fish from remote waters for consumption leads to large-scale accumulation of food byproducts as waste materials in terrestrial and coastal regions. It places additional waste assimilation demands on natural ecosystems around urban centres, while depriving the remote ocean environments of materials that would have been cycled back with marine ecosystems as production inputs or used as feed for other fish species.

Furthermore, the massive amounts of fuel materials used in the relocation and indefinite storage of fish harvests at ultra-low temperatures (Figure 2.6) leads to the production of greenhouse gasses, which have only exacerbated the ongoing climate change crisis. Rises in ocean temperatures and acidification of marine waters have resulted in further degradation of ocean habitats, reducing the natural productive capacity of the oceans. The imbalanced transfer of materials and metabolism of energies within the contemporary fisheries industry results in fractured marine food webs[21], and places further ecological pressures on already-stressed natural environments at multiple geographies—remote marine regions where fish are harvested and terrestrial urban centres where fish are consumed.

The destruction wreaked by modern industrialised fisheries are felt not only at the species level, but extends to other inhabitants within ocean ecosystems as well. The equipment and techniques employed to efficiently extract fish out of water have led to larger, ecosystem scale effects that further stunted the recovery abilities of the oceans in the aftermath of fishing activities. The typical techniques utilized by large scale fisheries, such as long-lining and trawling have resulted in massive quantities of collateral bycatch and destruction of key ecosystem features such as kelp forests and coral reefs[22]. These features are often rich in biodiversity and form key habitats for marine species from across all trophic levels, including juvenile populations of apex species. The loss of such habitats significantly reduce available resources crucial to marine biomass recovery.

Furthermore, as these fishing vessels move farther away from terrestrial-based administrative bodies, their activities become ever less transparent and regulatory oversight becomes increasingly more difficult. These fleets sailing on the high seas

Figure 2.7 - Bluefin Tuna feedlot off the shores of Port Lincoln, Australia [SMF, 2015]

are often rife with complaints of exploitative labour conditions and mistreatment of marine environments[23]. Their catches are frequently underreported and waste freely discarded into the oceans. The latter, particularly the discarding of unwanted fishing nets made with long-lasting materials, results in ghost fishing[26] and further loss of marine life and habitats. This present system of industrialized fisheries is an extraction model that relies on continued access to "cheap natures", where work performed outside of the commodity system is left unaccounted for[25]. It overlooks the unintended consequences of fisheries activities and reflects a devaluation of work that is carried out by both human and extra-human natures. As vessels depart ever further away from near-shore waters into the high seas in order to follow dwindling fish populations, the destructive scarring left behind by these operations have expanded alongside the growing footprint of operation.

There have been several different approaches to managing these issue of scarcity and ecological destruction. One response has come in the form of aquaculture, which has allowed producers to exert greater control over the growing conditions of their harvests while keeping the majority of their operations to near-shore waters[26]. Proponents of aquaculture claim that this is a more ecologically sustainable method of fisheries harvest, allowing them to extract fish from the farm on-demand according with market conditions[27]. In reality, aquaculture leads to and exacerbates the same metabolic imbalance created by conventional fisheries harvests[28].

Apex predator fish, especially an endothermic species such as the Bluefin tuna, have incredibly inefficient biomass conversion ratios. In order to producing 1kg of Bluefin tuna, the fish must consume 25kg of feed, often in the form of imported catches of feed species such as sardines and herrings from developing nations (Figure 2.7)[29]. This not only deprives local communities of what was supposed to be a readily available food source, but also forces coastal ecosystems where these farms are located to process much higher quantities of waste which eventually accumulates in those waters[30]. Consequently, aquaculture actually intensifies the metabolic rift as opposed to mending the rift.

Another approach to addressing dwindling fish stocks for many species is to establish restrictive fishing quotas, temporary species-specific fishing moratoriums or even entire no-take zones. These measures are often met with strong opposition from the fisheries industry, who argue that they deprive workers of their livelihoods and hinders regional economic development[31]. With little political will on the part of regulatory bodies to strictly enforce fishing regulations and put an end to the overexploitation of our oceans, many existing conservation policies have been ineffective in its biomass recovery agendas. Instead, we witness a worsening of the marine crisis. The fisheries industry have typically responded to quotas and moratoriums by shifting their energy from the extraction of one species to another, a pattern that fisheries scientist Dan Pauly describes as "fishing down the food chain"[32]. The further fragmentation of marine food webs hinders any recovery efforts by well-meaning bodies.

Unfortunately, the ecological cost of our culinary culture can no longer be ignored. It is clear that we cannot continue pillaging the oceans and its inhabitants for food as we once have. Urgent changes must be made to commercial fisheries practices in order to protect the long term ecological health of marine landscapes and its aquatic inhabitants. The decline of fisheries throughout the world is evidence that we have reached a critical point for both marine species and fisheries workers, but how can these two agendas be balanced within environmental development programmes when they seem so diametrically opposed to one another?

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(Co-)Productive Conservancy

3.1 (Co-)Productive Conservancy

The conservancy of natural landscapes, and their associated flora and fauna, is often pitted against anthropogenic activities as forces that work in opposition to one another[1]. The exploitative manner by which modern fisheries operate[2] and the voracious appetites of affluent diners for upper trophic level marine species lend evidence to that conclusion. One of the ambitions of conventional conservation projects is to reverse ecosystem damage caused by the previous two activities and to return species-specific biomass measurements to *a priori*, pre-exploitation levels[3]. This is typically achieved by carrying out restrictions on fisheries activities, oftentimes through the establishments of species-specific extraction quotas and regional moratoriums[4]. However, these strategies neglect to consider the economic challenges faced by fisheries workers themselves as well as wider ecological implications for co-inhabitants of the larger ecosystem. By failing to account for a wider range of stakeholders within the fisheries system, they become counterproductive to long term conservation goals to protect ecosystem integrity. They may even lead to further ecosystem decline as a result of added pressures on lower trophic level species[5]. It is therefore of utmost importance that measures to address the marine biomass crisis take into account both the cultural and economic impacts on social development as well as ecological impacts on the oceans.

While the extent of the damage that industrialised fisheries have wreaked upon ocean ecosystems is certainly great, it is not unimaginable that we may yet be able to rehabilitate these landscapes by adapting fisheries activities and coastal developments to support more sustainable marine food production practices. Given the dependency of fisheries communities upon healthy ocean environments and thriving marine populations, production (and subsequent consumption) activities can only exist in tandem with effective conservation programmes. It is necessary to create a *(co-)productive conservancy*, in which production and conservation strategies are utilised as part of an integrated process, and production activities are carried out by both human and extra-human occupants within the landscape. This means engaging fisheries workers, the human stakeholders most vulnerable to ecosystem collapse, as part of the conservation strategy. More importantly, it is the currently disadvantaged, small-scale fisheries producers that ought to be included as many have already been excluded access to fish stocks within the framework of existing regulations[6]. This model of marine conservation and production would require reconfiguring the human-nature relationship from its presently fractious and imbalanced hunter-prey dynamics to one of equal co-guardianship of the landscape. The resulting partnership is a paradigm shift in fisheries management that acknowledges the crucial role humans and nature each play in the other's long term development and existence.

Rather than limiting marine conservation work to activists, scientists and political administrative bodies, an effective *productive conservancy* needs to engage with all three major stakeholders within the fisheries system: fisheries workers, marine species and public consumers. It would reposition fisheries workers and even the public consumer as stewards of marine landscapes and contributors to sustainable natural processes. Harvest and extraction activities of marine species would be treated as part of maintenance programmes to ensure ecosystem balance and the proper functioning of marine landscape structures, while consumption activities would play a role in (re)cultivation and ecosystem enhancement efforts. At the same time, *productive conservancy* projects must provide opportunities for direct engagement between consumers and the landscape in order to highlight our dependence on marine biospheres[7]. Given that cultural practices such as dietary patterns are ever evolving, these engagement opportunities would reveal to visitors the biodiversity of ocean landscapes and help to redirect consumption habits towards lower trophic level species that require fewer primary units of production. Doing so would begin to mend the previously described metabolic rift and end the alienation of human from nature.

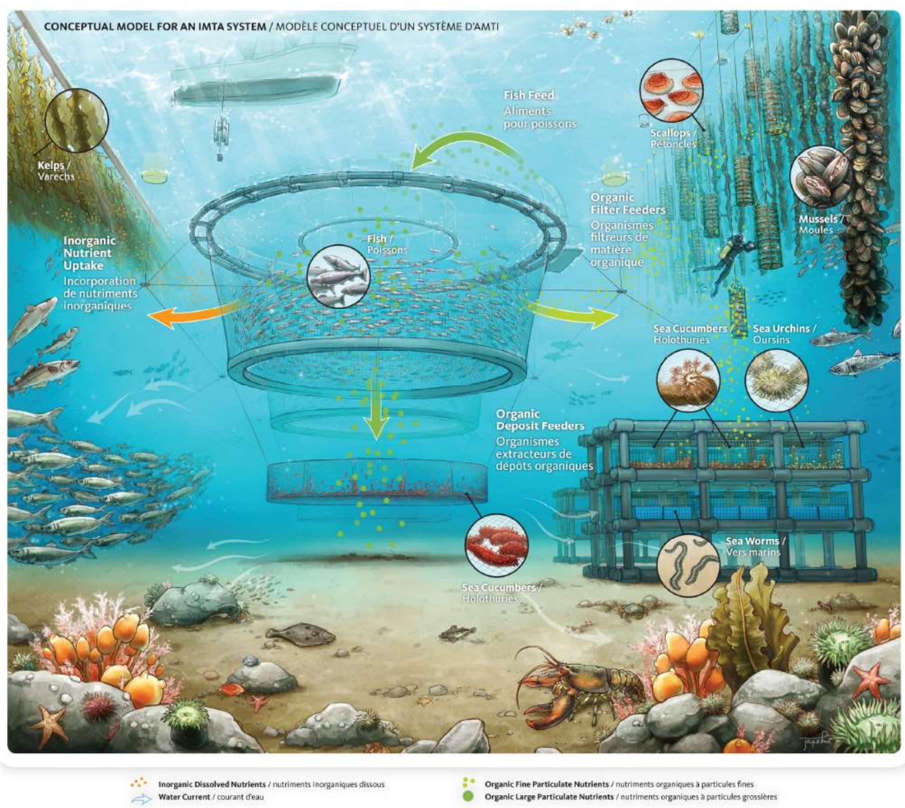

Figure 3.1 - A conceptual diagram from Fisheries and Oceans Canada illustrating the relationships between various species within an integrated multi-trophic aquaculture programme [Government of Canada, 2018]

The *productive conservancy* strategy should engage with species from all levels of the food web as part of the production system. It can take advantage of syntrophic marine relationships and natural ecosystem services provided by each species to limit resource consumption and disruption to local environments [Figure 3.1][8]. Examples of integrated, multi-species fisheries production can be found in various forms throughout many parts of the world, each demonstrating a different approach towards achieving holistic and sustainable fisheries. Some, such as GreenWave's 3D Ocean Farming initiative in the USA, are more economically driven. It focuses on

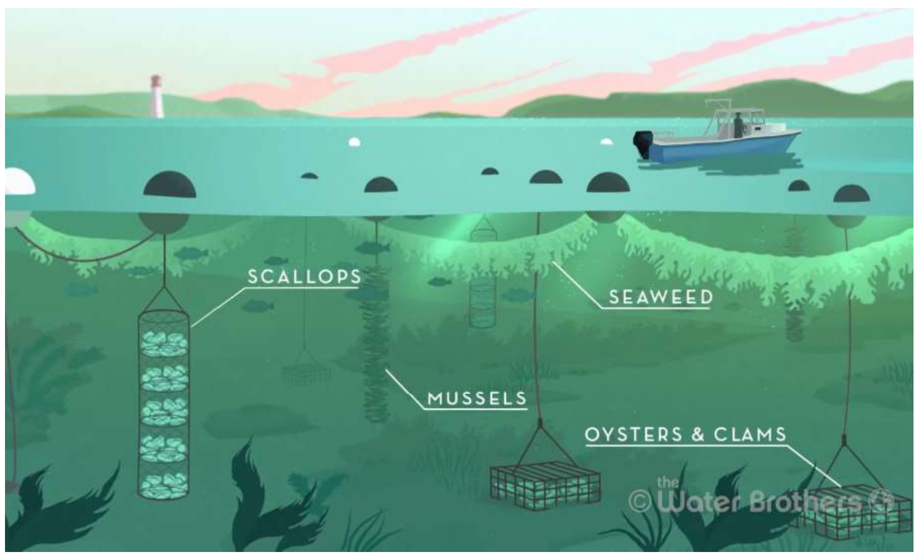

Figure 3.2 - Thimble Island Ocean Farm, one of the first GreenWave projects [Greenwave, 2017]

harnessing specifically the relationships between species targeted for production and their ecological/landscape functions [Figure 3.2][9]. GreenWave describes this as the cultivation of the entire water column. Others, such as the Mai Po Nature Reserve in Hong Kong, utilizes fisheries activities to generate enhanced regional biodiversity and support the conservation of coastal species [Figure 3.3] while incorporating amenities to support public engagement[10]. The site retains vernacular fisheries techniques as part of its conservation programme, allowing the local community to maintain its livelihood while ensuring ample opportunities for co-occupancy of the landscape by migratory birds and regional marine life.

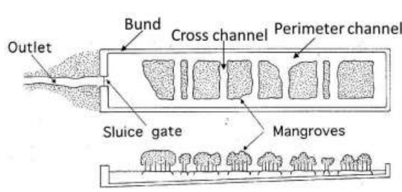

Figure 3.3 - Tidal shrimp ponds (gei wai) at Mai Po Nature Reserve, Hong Kong function as a cultivation site for local fisheries as well as a feeding station for migratory birds and an educational park for visitors. [Counterclockwise from top: Veronica Zaragovia, 2010; WWF, 2017; Richard Wright, 2012]

The notion of *productive conservancy*, where human economic activities assist in efforts to enhance ecosystem health, has recently been incorporated into environmental and food policies in Japan. The National Biodiversity Strategy of Japan 2012-2020 designates the concept of *sato-umi* as a key part of biodiversity preservation projects. First introduced by Japanese oceanographer Tetsuo Yanagi, *sato-umi* describes coastal sea areas with high (natural) productivity and biodiversity through human interaction with the marine landscape[11]. These interactions include selective, periodic disruptions to the landscape that allow landscapes to cycle back to earlier stages of development such as by destroying parts of a landscape as well as the construction of new artificial landscape elements that allow biota to thrive. By designing these disruptions into the landscape, it shifts ecosystem management from a principally economic perspective (focusing particularly on profit-making) to long term management of human activities and actions within an ecosystem.

Productive conservancy adopts a risk-diversification, bottoms-up approach to economic production and ecological conservation. Conventional top-down approaches such as fishing bans only limits extraction activities, but does not address the need to improve the administration site's productive capabilities, a necessary part of population recovery and especially crucial in the face of amplified climate change[12]. Nor do these measures account for the need to seek out alternative economic activities. Oftentimes, they have even exacerbated ecosystem imbalances[13]. These reductivist management practices have also been ineffective in protecting the populations they targeted because they tended to favour strict definitions of landscapes and environmental actors by rendering the interior distinct from exterior—as though species exist as homogenous cultures in isolation. Such distinctions are especially counterproductive when managing migratory species and complex marine food webs. The *productive conservancy* strategy focuses on enhancing primary production at lower trophic levels to support the recovery of overexploited apex species. It is a holistic strategy which aims to create optimal conditions for multiple species to grow and intensify overall ecological productivity. This method of biomass recruitment, described as "parametric fisheries management" by James Acheson[14], not only allows juvenile population of apex species to thrive, but also prevents the fracturing of complex marine food webs by providing increased food sources for growing populations at multiple trophic levels. It enables marine ecosystems to better absorb and handle external stress caused by natural and man-made forces.

In order for *productive conservancy* to be effective, it is important to recognize that natural ecosystems are not objects that remain in stasis upon achieving an optimal climax stage, but rather, a set of processes that allow landscapes to exist at various developmental stages and remain in flux at many scales[15]. In short, they are "shifting steady-state mosaics"[16]. The goal of productive conservancy, therefore, is not to create a time capsule of an ecosystem. Instead, it should be to work with and enhance the underlying ecological processes that informs the ecosystem. Therefore, amendments to the environment can take the form of additive constructions as well as selective removal of landscape elements and marine species. Crucial to the effective execution of this agenda is an understanding of the multi-trophic, interspecies relationships [17]and multi-scalar timelines that shape the marine environment, as well as the potentials that human intervention can reveal in the landscape.

Another factor to consider when designing for *productive conservancy* is the material cycling processes that occur in the oceans, particularly in coastal sea areas that are most heavily affected by human terrestrial activities. Activities within a *productive conservancy* should help to minimize the impacts of land-based activities on marine environments and enhance the ability of natural systems to assimilate excess materials. A *(co-)productive conservancy* should highlight the co-occupancy of many species within the landscape.

Endnotes

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The Productive Marine Refuge of Oma

Figure 4.1 - A wholesaler drags a frozen Bluefin tuna across the hall at Tokyo's Tsukiji Central Wholesale Market [Kato, 2010]

Figure 4.2 - Kiyoshi Kimura, poses for a photo with his prize on the first trading day of 2018 at the Tsukiji fish market [Kawasaki, 2018]

4.1 The Hinterwaters of Honmaguro

Hatsumaguro, the opening Bluefin tuna auction of each year at Tokyo's Tsukiji Central Wholesale Market (Figure 4.1), is an exciting affair that attracts the attention of the city's major media outlets. The eye-watering prices that the first auction fetches are regarded by traders and observers as an auspicious sign for the year ahead[1]. Competition for the prize is fierce and often results in a bidding war that leads to incredible fortune for the fisherman who had caught the fish. In 2018, the first tuna, a 405 kg giant, was sold for a record-breaking final price of ¥36.45 million to Yukitaka Yamaguchi of Yamayuki Group, a wholesaler based at Tsukiji[2]. He had beat out Kiyoshi Kimura, the owner of a national sushi restaurant chain called Sushi Zanmai who had won Tsukiji's *Hatsumaguro* auction for the previous seven years (Figure 4.2). Just as in previous years, the prized fish was landed at Oma, a small town of 5,500 located in the rural prefecture of Aomori. Outside of Japan, the remote community is little known, but sushi connoisseurs will quickly recognize it as the landing site of some of the most prized Bluefin tunas found at markets and restaurants across Japan.

What makes the catches landed at Oma so coveted by restaurateurs and gourmandes alike is a combination of two factors. Firstly, the town's geographic location, at the northernmost point on Japan's main island of Honshu, means that it is best positioned to take advantage of the surrounding fast-moving, cold waters of the Tsugaru Strait during the fall and winter months when Bluefin tunas migrate through the region (Figure 4.3). These icy waters carried by the Tsugaru Current which flow through the

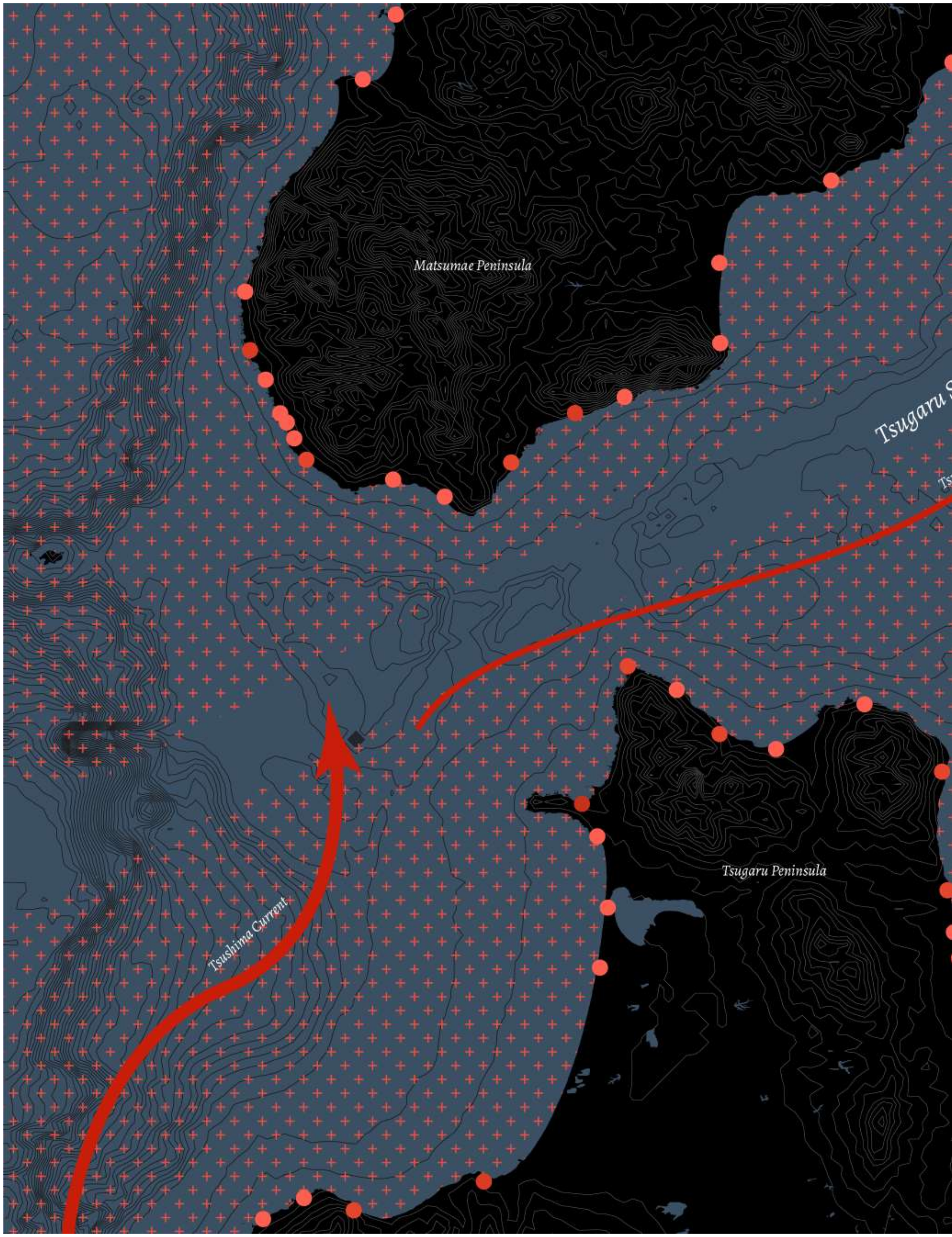
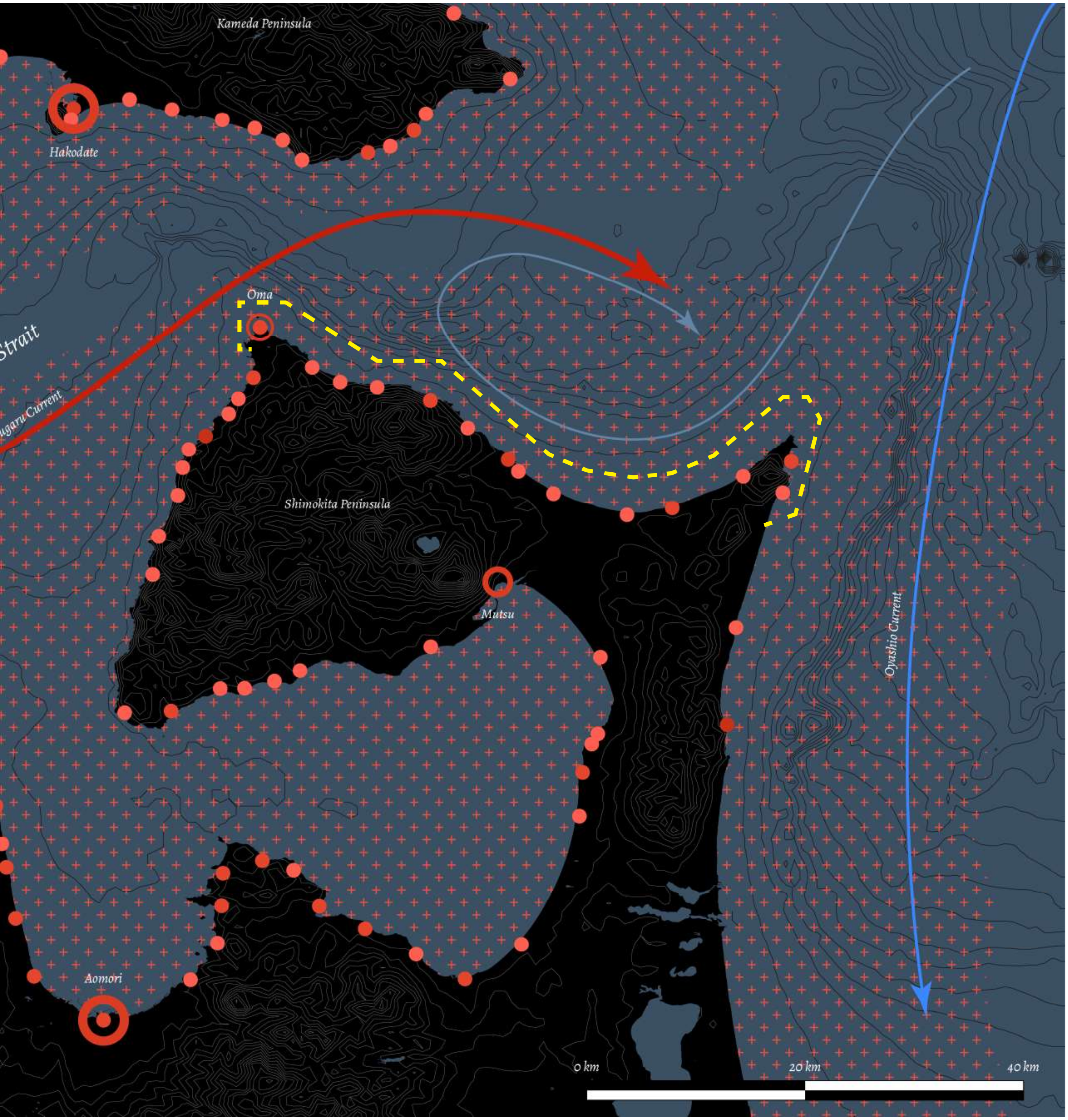


Figure 4.3 - A map of the Tsugaru Strait Region; The yellow line indicates the series of potential sites that can be reconfigured to form a larger regional Productive Marine Refuge Network


Kameda Peninsula
Hakodate
Strait
Tsugaru Current
Oma
Shimokita Peninsula
Mutsu
Oyashio Current
Aomori
0 km
20 km
40 km

strait creates the perfect conditions for producing optimal tuna flesh for the market, ensuring that the fat content is as high as possible[3]. Meanwhile the nutrient-rich upwelling brought by the nearby Oyashio Current results in waters with an abundance of fish from a variety of species across all trophic levels and attract Bluefin tunas to feed in the region[4]. Historically, these conditions have led to incredibly fertile fishing grounds for the local Bluefin tuna fishery.

Secondly, the town of Oma is deeply committed to the pole and line method of fishing, where Bluefin tunas are taken out of the water one by one. Not only does this method have a lower environmental impact, it also minimizes damage to the fish's flesh, which could potentially lower the price when the fish arrives at the auction. Thus, despite the lower harvesting efficiency, the tunas landed by Oma's local fisheries are considered by industry insiders to be some of the best specimens of its kind found at wholesale markets[5].

Figure 4.4 - Oma's monument to its Bluefin tuna fisheries

The northern prefecture of Aomori is amongst the poorest regions of Japan, ranking 40 out of the country's 47 prefectures according to 2014 figures on per capita GDP[6]. It still heavily relies on its agriculture and fisheries sectors as economic drivers. Bluefin tuna, with the exorbitant prices that it commands in faraway urban markets, are a huge economic boon for the town, bringing in ¥1.6bn to the town annually[7]. The town takes so much pride in its tuna that it has established a regional collective trademark for "Oma Tuna" in 2007[8] and even created a monument to celebrate this local treasure (Figure 4.4). But with the impending commercial extinction of the species, Oma Tuna may soon be a thing of the past. Already, the town is witnessing a decline in their catch[9]. It struggles to compete against the far more efficient extraction capacity of trawlers and purse seiners who manage to remove the tunas from surrounding seas and oceans before they manage to arrive in the local waters of the Tsugaru Strait.

The challenges faced by Oma's fisheries sector are not unique to the town. The Tsugaru Strait region is home to over one hundred fishing ports ranging from Class I to IV. Japan's fishing port classification system denotes the scale of operations and management structure of a fishing port. Many of these fishing ports in Class I and II belong to communities where small-scale fisheries play an important role in the local economy and are managed by local fisheries co-ops. As the current marine crisis worsens, these fisheries workers will find it increasingly more difficult to continue to compete against large scale fishing operations and earn their livelihoods from fishing. The urgent challenges faced by the fisheries sector of this region presents an opportunity to rethink the role of fisheries workers and the development of coastal amenities in order to support a more sustainable model of fisheries.

While the general fisheries industry is often associated with extraction activities from marine environments, one solution to the impending crisis may be to reconfigure fisheries workers as in-situ stewards of regional waters and adapt their activities to foster the revival of local ecosystems. This thesis proposes the establishment of a regional Marine Protected Area (MPA) along the northeastern coastline of the Shimokita Peninsula. Existing local fishing ports, and their associated waters and shorelines will be redeveloped into a series of small Productive Marine Refuges (PMR) in which fisheries activities are carried out with the express aim of creating greater biodiversity and rehabilitation of marine biomass in the region. This network structure, which relies on a greater number of confined, monitored territories, would more effectively utilize the limited amount of resources (both labour and and financial capital) available to the region and improve the probability of success in its conservation agenda[10].

At the same time, this proposal still seeks to provide local fisheries with adequate revenues not only to support the long term development of the local economy, but also to provide the necessary funds to continue its ecological rehabilitation projects. In addition, it seeks to mend the metabolic rift created by existing fisheries practices and exacerbated by conventional aquaculture methods. The fisheries activities in this region will focus on the production of high-value seafoods which occupy lower trophic levels—and the driving principle here is truly production rather than mere extraction—in order to shift fisheries pressures away from apex marine species, while reduce the fracturing of marine food webs. The species targeted for cultivation would rely strictly on the the availability of food and nutrients from local waters, and their harvesting would support both human and marine populations. This means the cultivated species must provide both human gastronomic and natural ecosystem services, whether directly as food for higher trophic level species or support other activities in the landscape.

Thus, the key species that will enable the renewal of Shimokita's fisheries and marine ecosystem will be native oysters, sea urchins and kelp species which will be farmed in near-shore waters. The revenues derived from the harvesting of these species will allow the region to establish a series of seagrass meadows and oyster reefs, which will not only boost local biodiversity from the foundations of the trophic web and create new habitats for multiple marine species, but also enrich the waters for migratory species moving through the region.

The town of Oma is the first within this proposed MPA network (Figure 4.3) to undergo a transformation into a Productive Marine Refuge. The proposal combines socio-economic development and ecological rehabilitation together in a singular project. Through a phased development programme, it presents a kit of parts that will foster both the revitalization of marine biomass as well as provide alternative revenue streams for the community. This testing site will also be opened to the public so that consumption culture can become informed by sustainable production practices.

Figure 4.5 - Masterplan for the Productive Marine Refuge of Oma

4.2 *The Productive Marine Refuge of Oma*

Located along the eastern shore of the town, the Productive Marine Refuge of Oma (Figure 4.5) takes advantage of a currently underused coastline and establishes a renewed interface between the activities on land and in the water. The initial phase of intervention on the site consists of nursery and greenhouse facilities that will be used to construct a seagrass meadow (1), a kelp farm (2) and a shellfish farm (3). These three components will not only support seafood harvests for the community and create new habitats for marine populations, but also perform larger ecosystem services such as wave energy attenuation and sedimentation control. The second phase of development focuses on providing a visible public interface for the park. The learning market centre (4) will act as a gateway to the site for out-of-town visitors and provide opportunities for education and commerce in addition to spaces for seasonal festivities and recreation. In addition, a shoreline promenade (5) consisting of a series of coastal vegetation terraces and breakwater ridges invites visitors to further explore in-situ the many species of marine flora and fauna that comprises the landscape. These last two components will support tourism activities that provide additional revenue which can be used to carry out conservation programmes. Through ongoing stewardship activities carried out by both fisheries workers and marine conservationists as well as public visitors, the site will become a testing ground for the integration of fisheries activities, landscape maintenance and biomass rehabilitation.

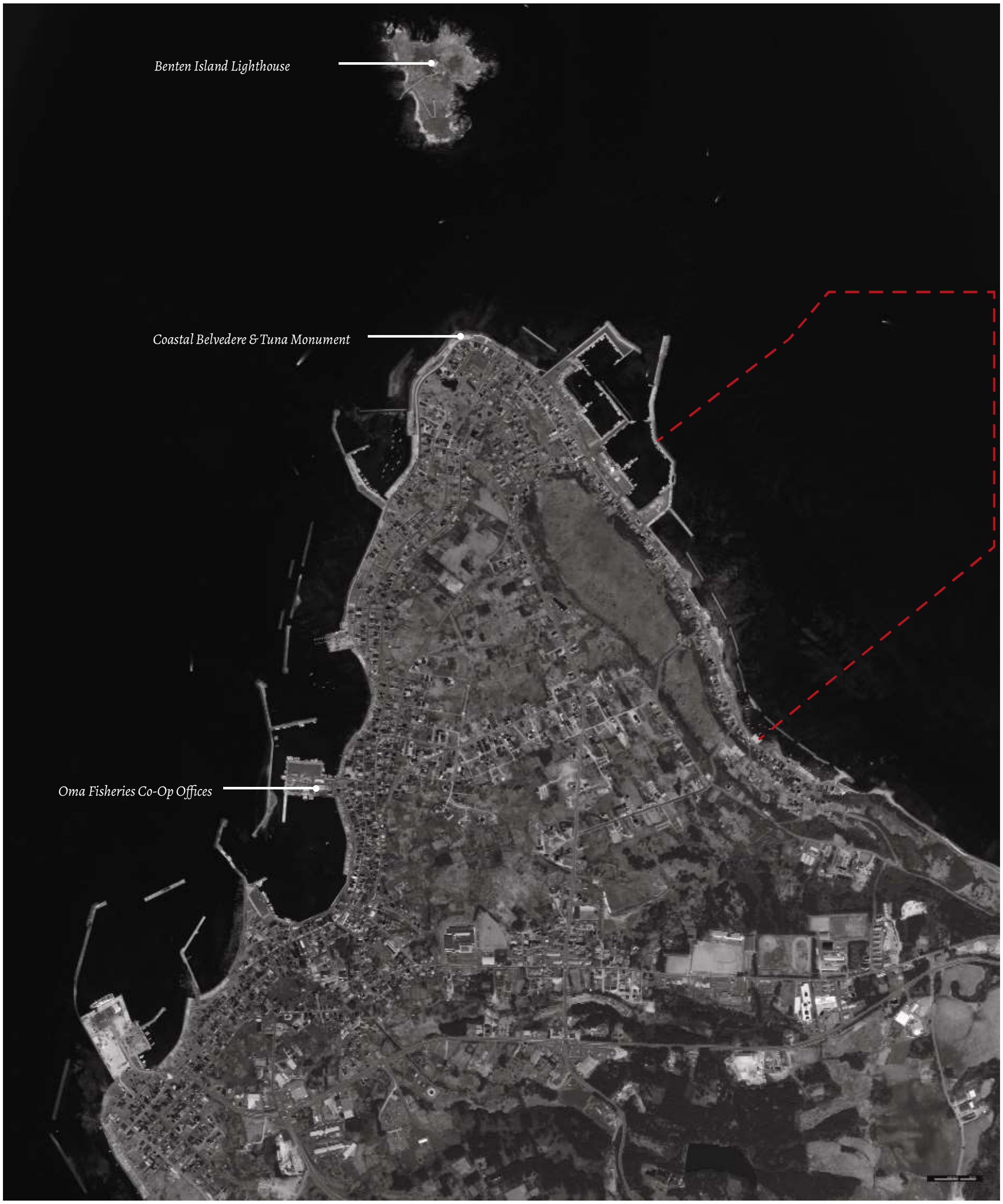


Figure 4.6 - A satellite image of Oma's existing development. The area demarcated in the dotted red line represents the boundaries of the proposed PMR.

Figure 4.7 - The ice-making facility at the eastern fishing port.

Existing Site Conditions at the Fishing Port

While fishing ports can be found throughout the entire perimeter of Oma (Figure 4.6), much of the town's fisheries industry is concentrated in the ports located along its western shore, where the current offices of the local fisheries co-op are located. Although the town is renowned for its tuna landings, there are few opportunities for visitors to experience the local fisheries culture. A very limited number of public landmarks pays tribute to the town's heritage northerly location by the sea, but provide little opportunity for extended engagement with the community.

Oma's eastern fishing port is currently an underused site with little activity and largely functions as a marina for squid fishing vessels. An ice-making facility that services local fishing fleets (Figure 4.7) and a massive breakwater wall that severs the community from the sea (Figure 4.8) are the only major structures on the site. The unused southeastern area of the port and its extended shoreline will host new facilities for the proposed PMR (Figure 4.9).

Figure 4.8 - The breakwater wall as seen from the northwestern entrance to the port.

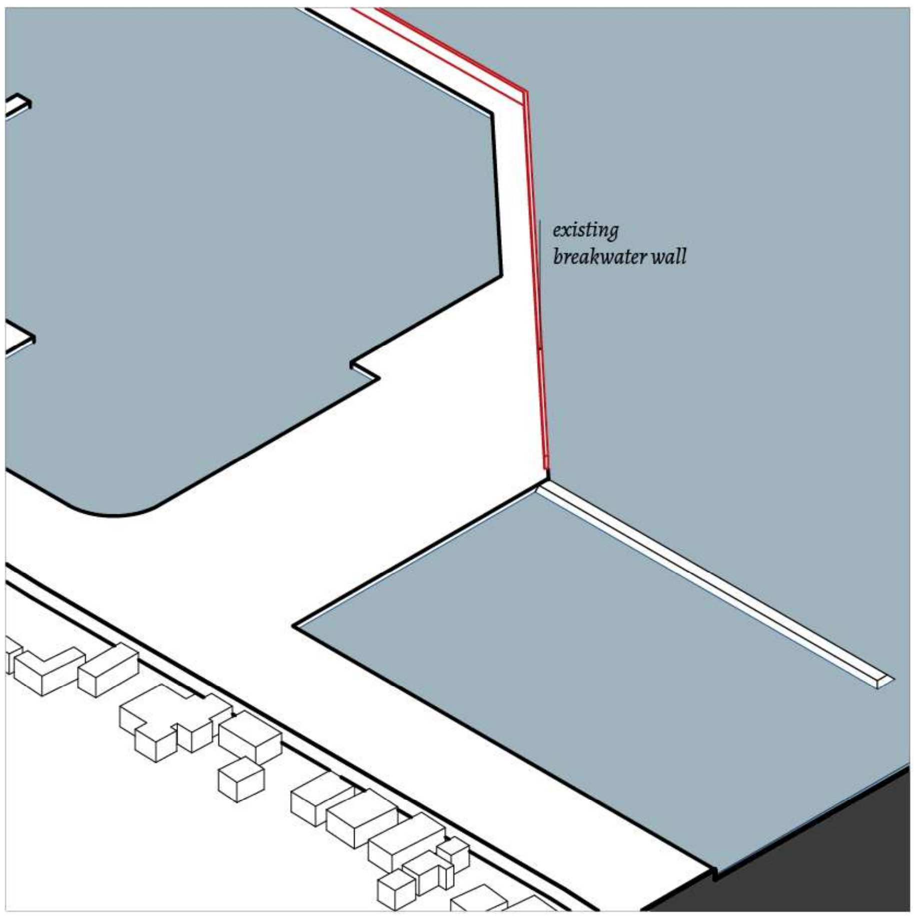


Figure 4.9 - Existing conditions at southeastern area of Oma fishing port.

Phase 1 Intervention - Initial Production Facilities for the PMR

Initial interventions on the site will consist of amenities used primarily as part of the PMR's biomass rehabilitation and ecological enhancement agenda. These include nurseries and greenhouses that will be used to establish marine nursery habitats for juvenile marine species as well as breakwater ridges will will provide additional surfaces for the growth of coastal biota. In addition, establishment of mariculture facilities in near-shore waters, including the oyster farm and kelp farm, will provide the necessary materials and resources to further the development of the park. The

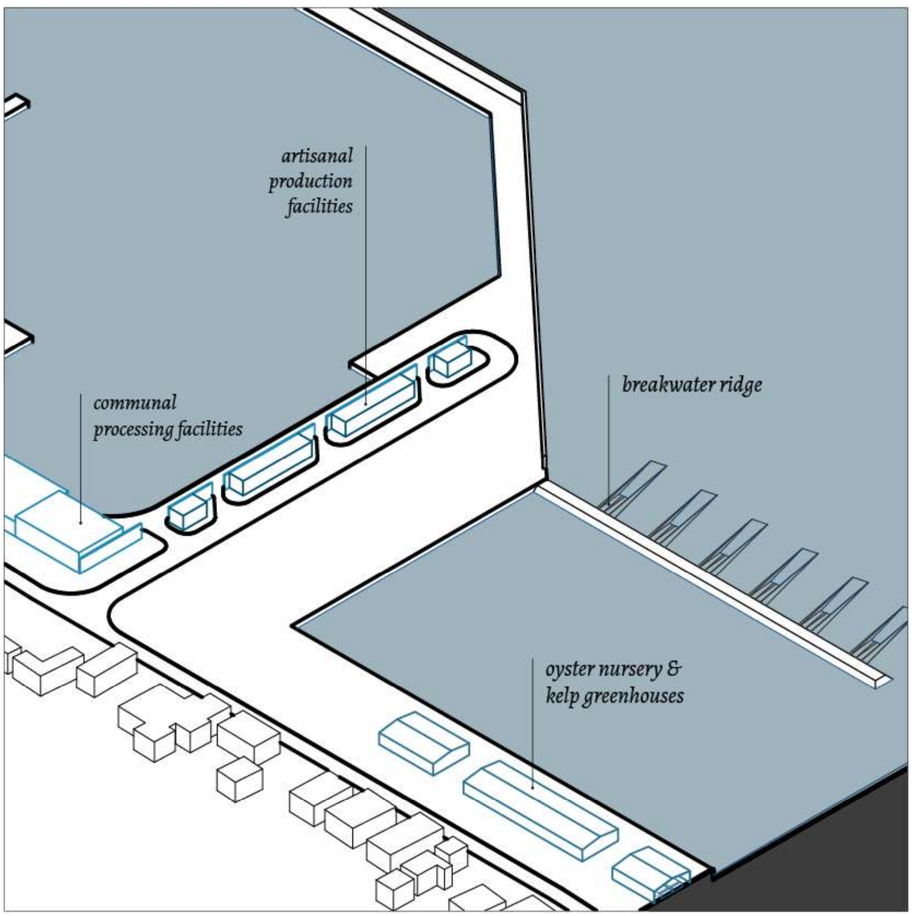


Figure 4.10 - Phase 1 modifications to the site.

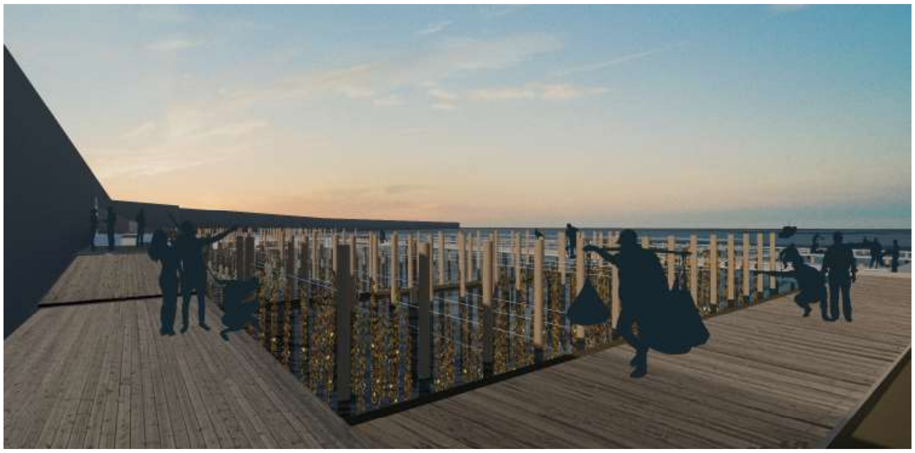


Figure 4.11 - The boardwalks on the other side of the wall opens up the shellfish farm to public visitors, giving them the opportunity to see the different species of shellfish that are cultivated on site.

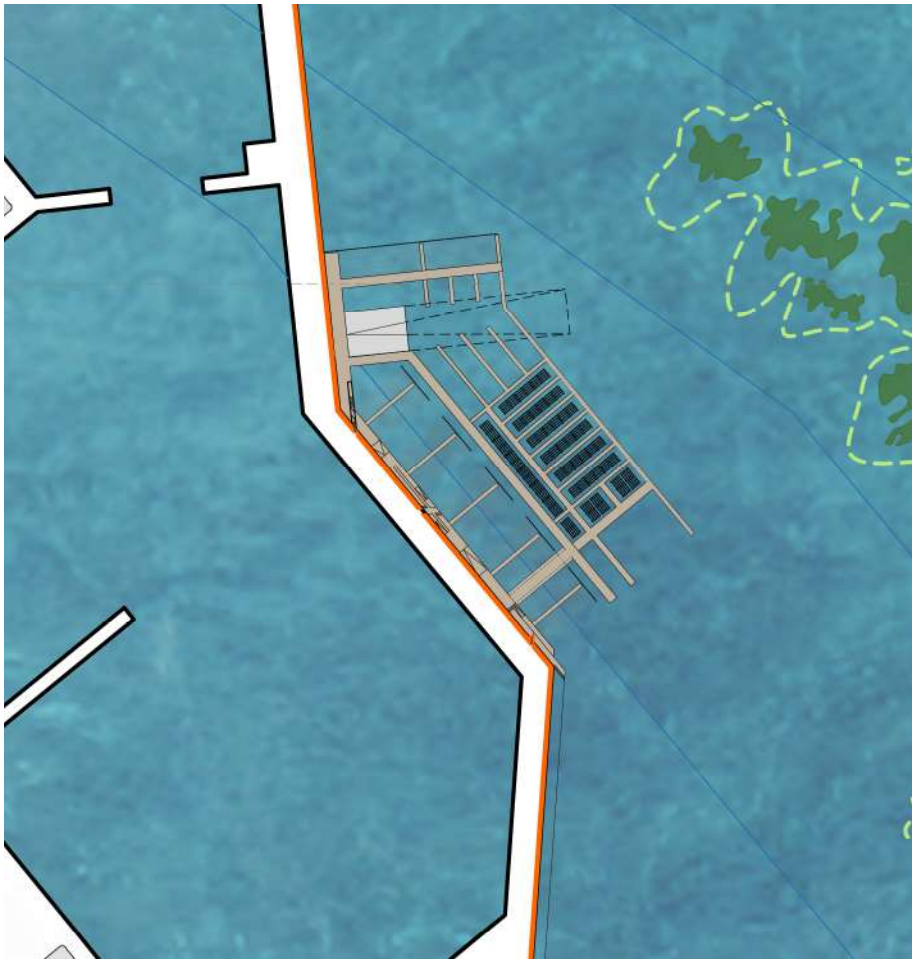


Figure 4.12 - Siteplan of the oyster farm boardwalks.

existing breakwater structures will be extended to create an initial observational playground for visitors to explore the first-stage changes and activities occurring at the PMR (Figure 4.10).

The Oyster Farm

Situated on the seaward side of the existing breakwater wall, the oyster farm (Figure 4.11 & 12) will provide the first additional source of fisheries revenue for the community as the local fisheries industry begin its shift away from its dependence on Bluefin tuna harvesting. The production of oysters is crucial for the development of the rest of the park. The shells collected after the consumption of oysters will be reused as materials for oyster culture and the construction of landscape structures in the park. As more oysters are produced and redistributed in the landscape to seed additional oyster beds and reefs, the water quality in the park will also begin to improve. This results in better habitat conditions for other fish species.

The boardwalks at the oyster farm will provide access to the farms for outside visitors. Oyster ropes suspended at various heights above the water level will form a series of shifting curtains that both obscure and unveil the landscape at sea. This space beyond the wall re-opens the sea as a landscape that visitors can occupy and observe, establishing the first opportunity for consumers to engage with fisheries activities within the PMR.

The Kelp Farm

The use of kelp (*konbu*) in Japanese cuisine has a long historical linage, and kelp from nothern Japan is highly prized. The kelp farm provides not only monetary revenues for the local fisheries industry through kelp production and processing, but can also serve as a habitat for local sea urchin species which feed on kelp. Thus, in order to preserve

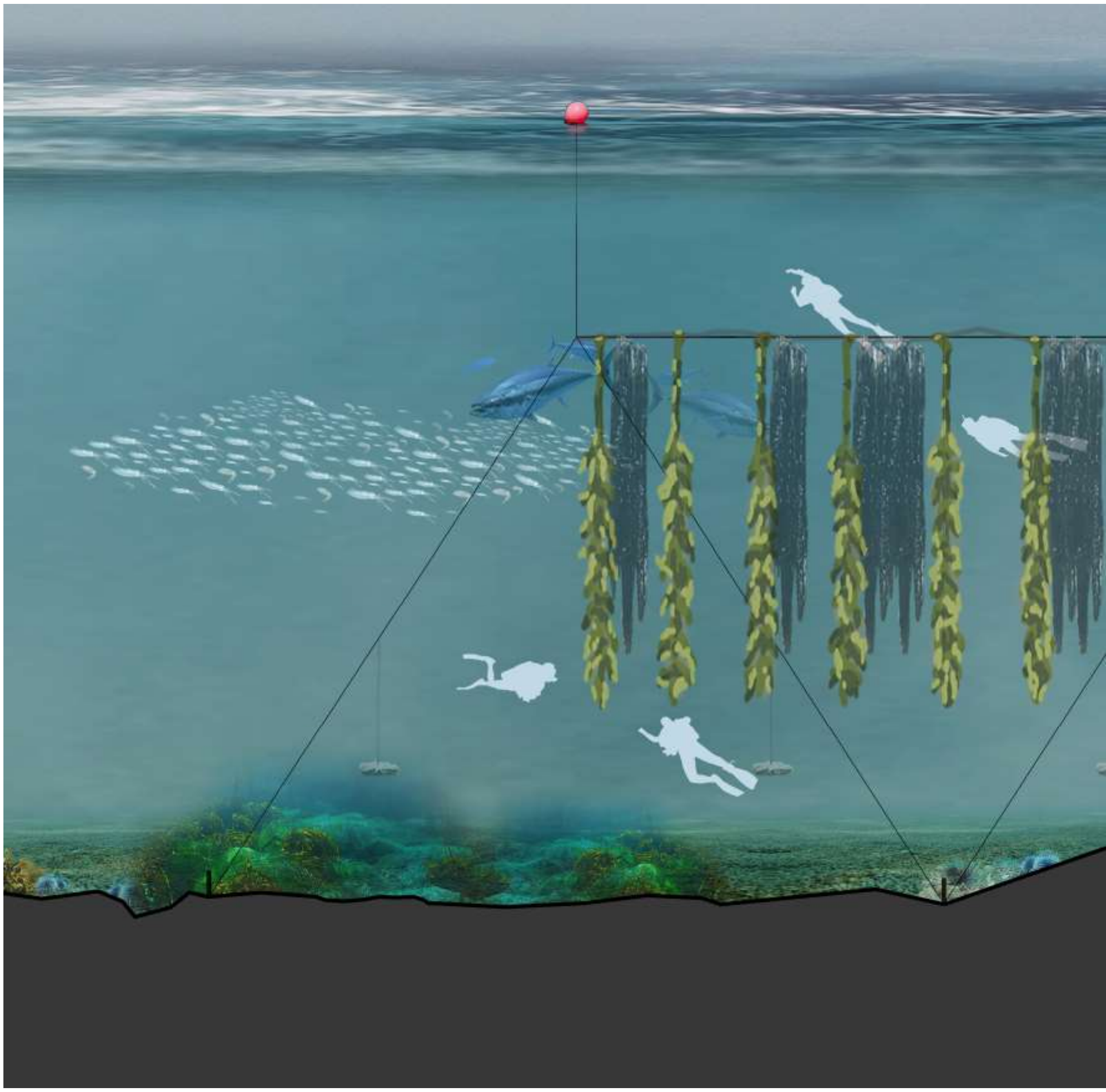
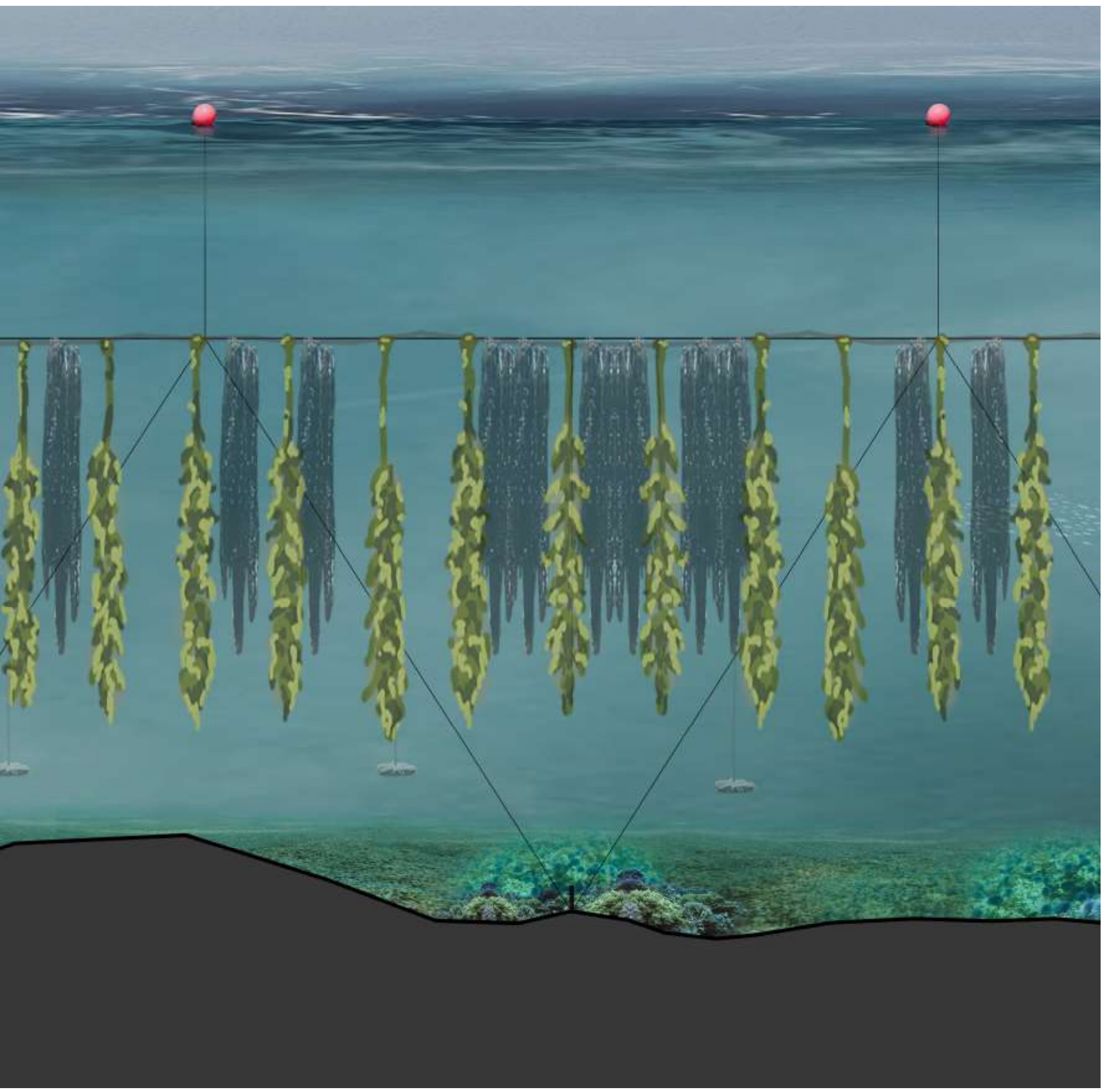


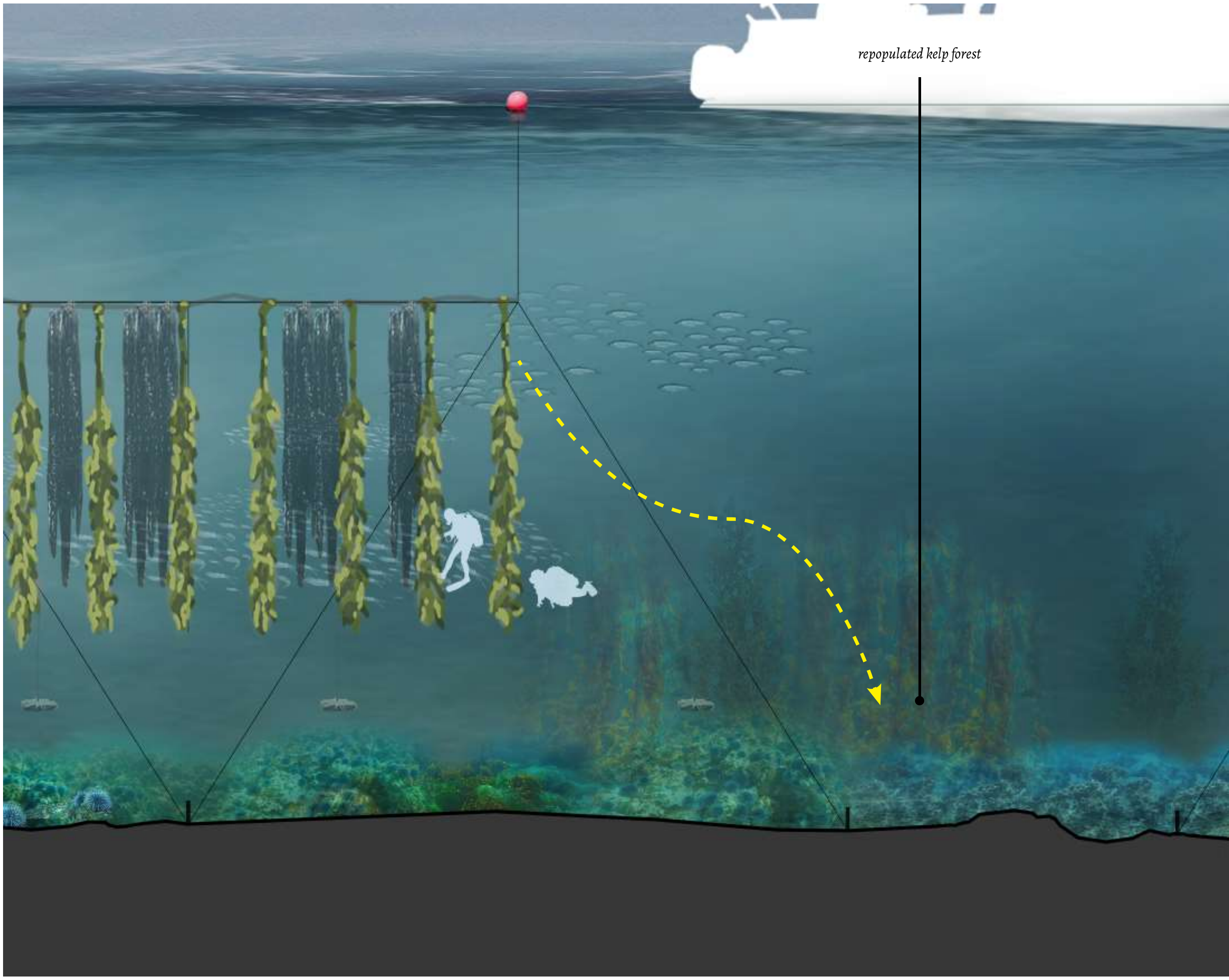
Figure 4.13 - Section through the kelp farm

adequate quantities kelp until they reach maturity at harvest time, it is important to carrying out periodic removals of sea urchins from the seabed (Figure 4.13). This careful harvesting of sea urchin is both an ongoing maintenance activity vital to the health of the kelp farm and an additional revenue stream for the community. It would shift the biomass production pressures off of higher trophic-level species

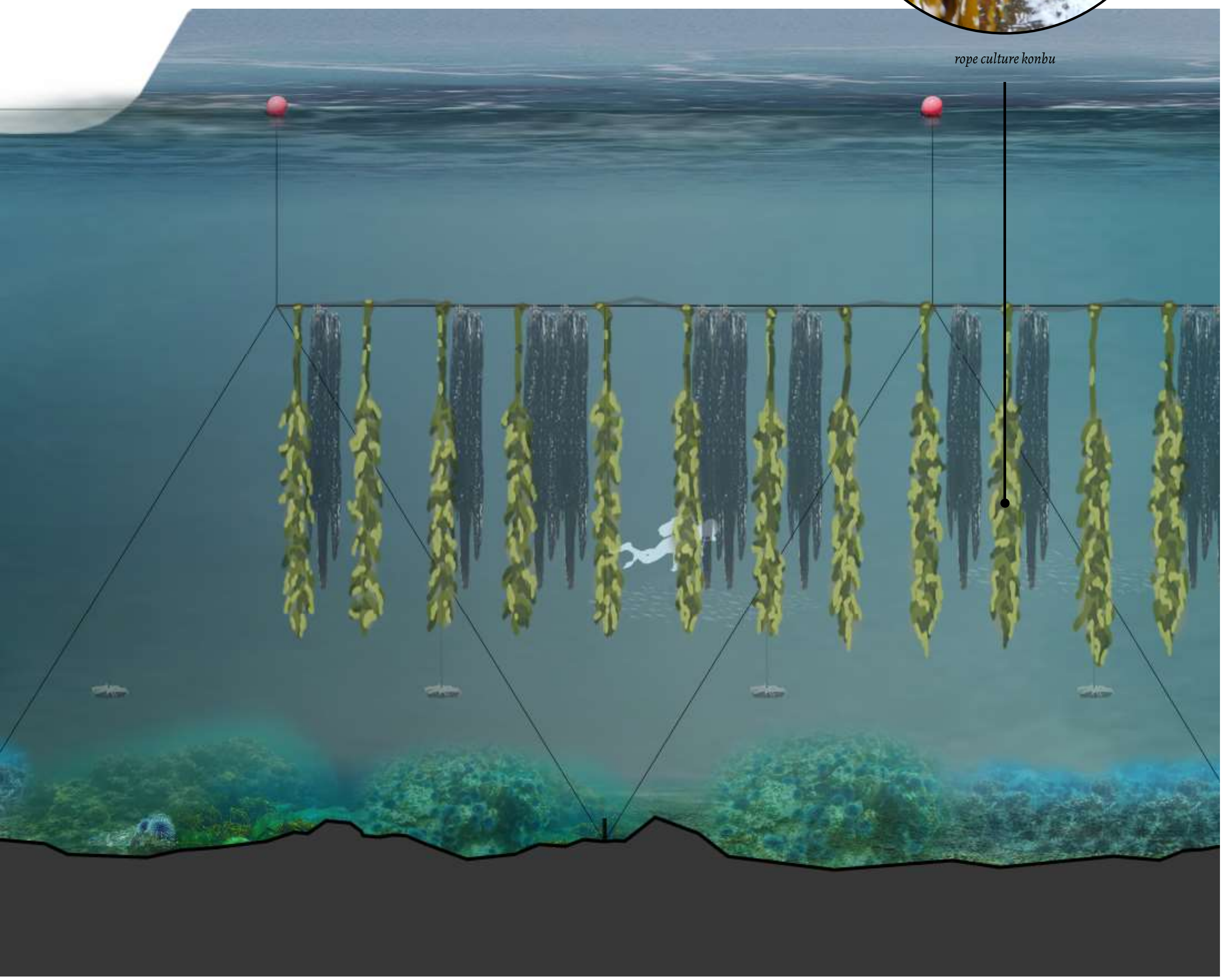


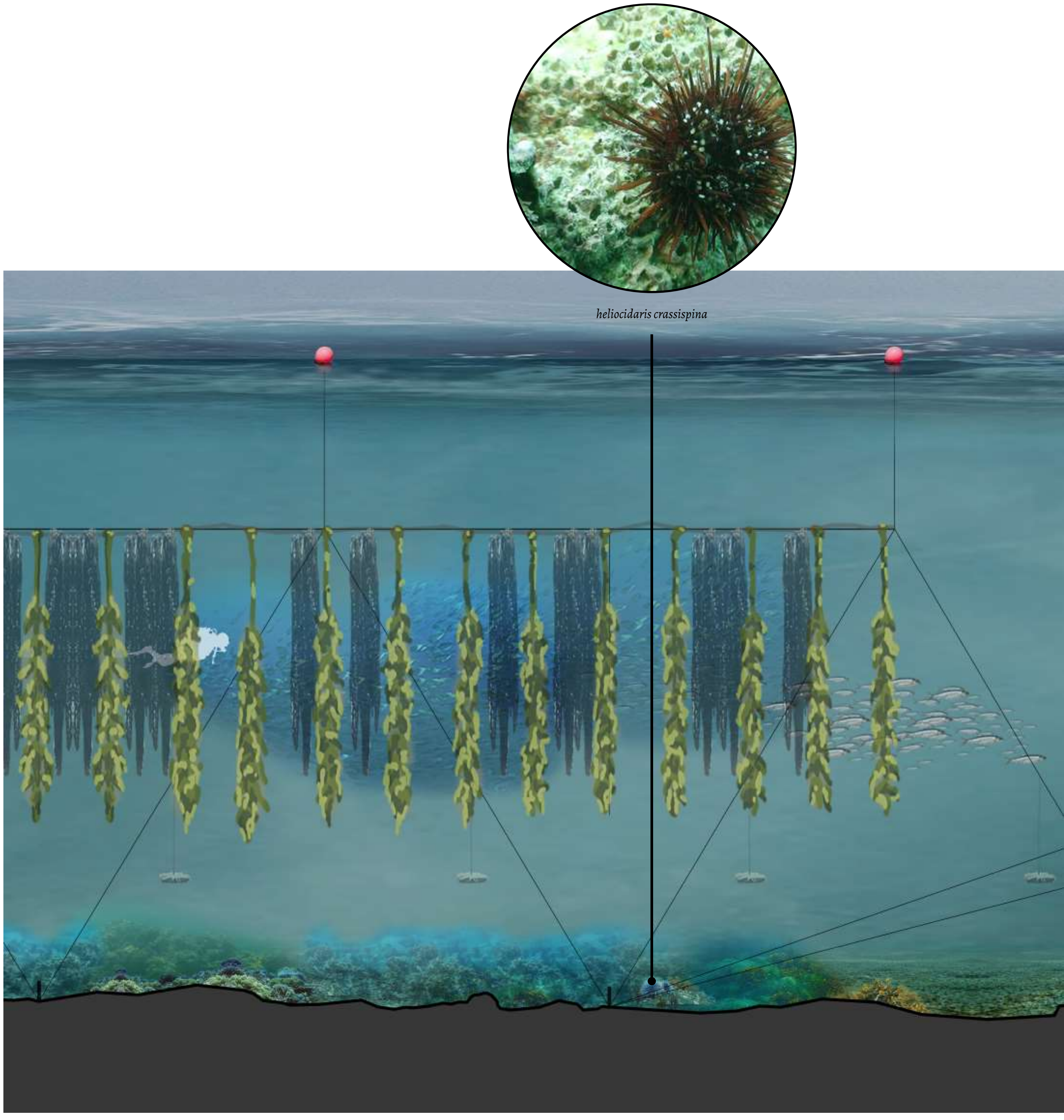
such as Bluefin tuna by introducing larger quantities of lower trophic-level species to the local site without creating additional pressures on existing marine populations. Furthermore, the sea urchins can also be consumed by other marine species for food.

As the site develops over time, spores from the kelp farm at the upper portion of



the water column would begin populating the seabed with new kelp fronds. This begins the establishment of new kelp forests at the site, which are necessary for the absorption of wave energy brought in by regional currents and seasonal storms.

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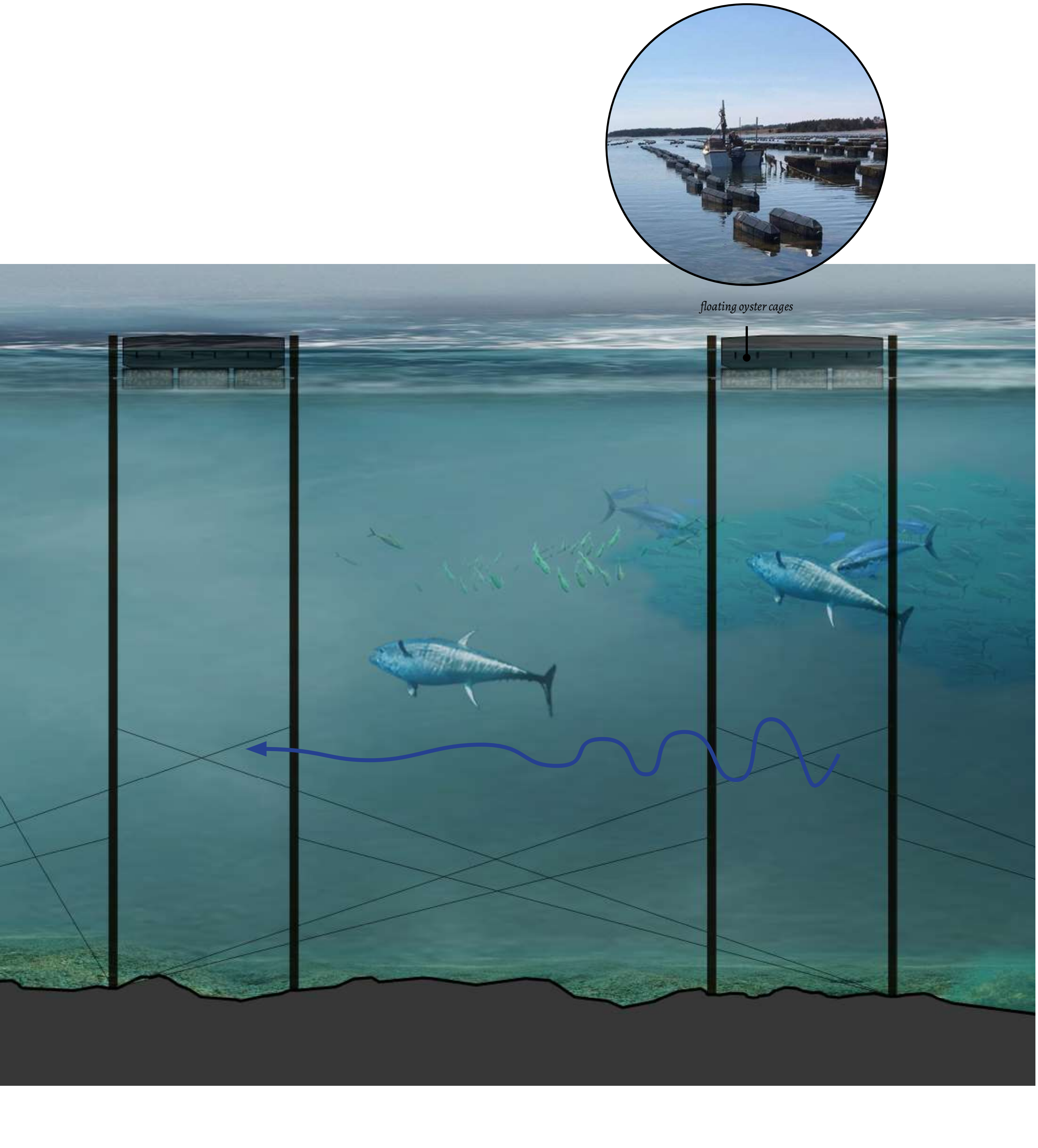
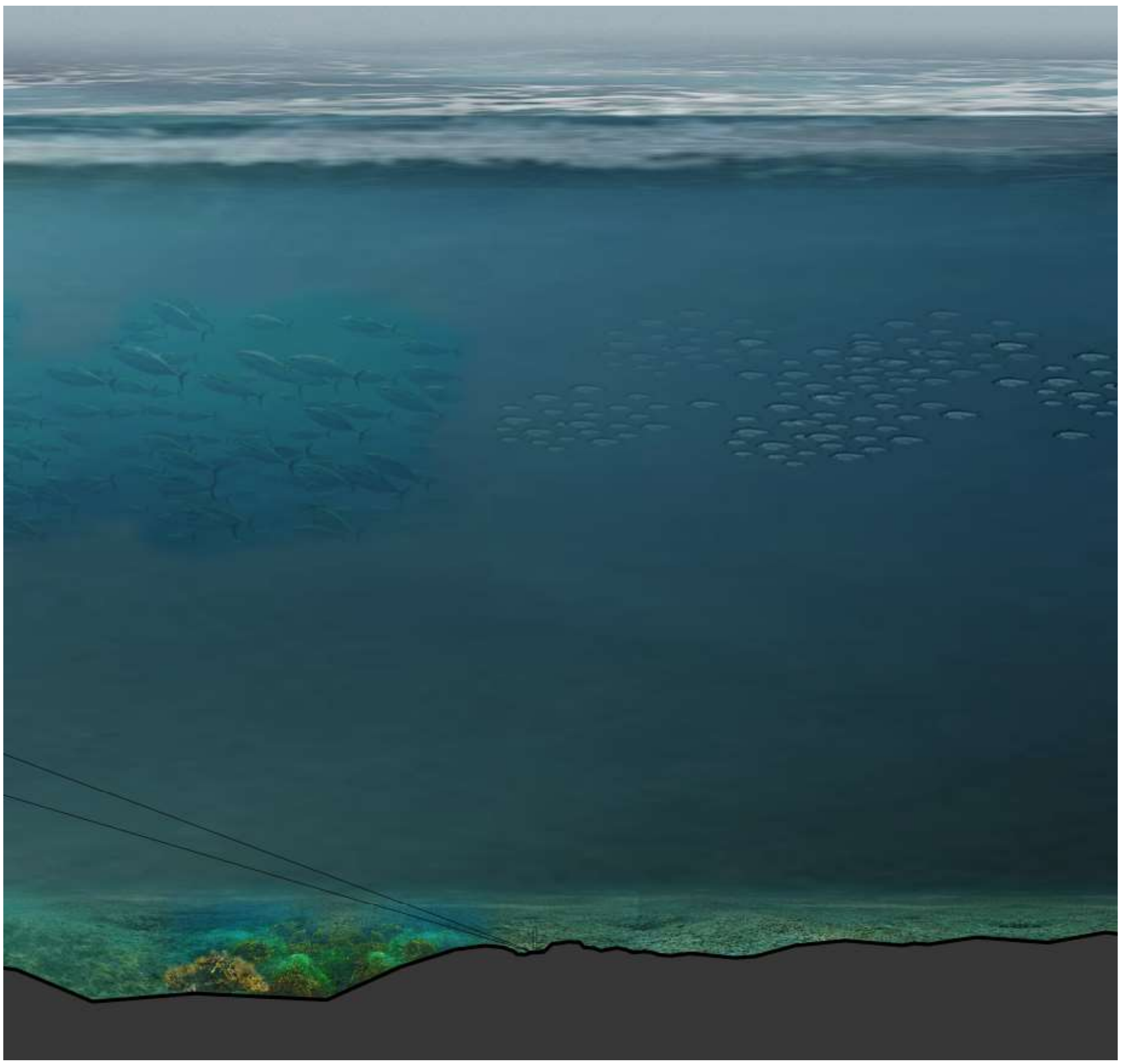

floating oyster cages



Phase 2 Intervention - Learning Market Centre & Shoreline Promenade for the PMR

The Learning Market Centre consists of six key volumes situated on either side of the extended wall and will serve as a gateway and museum to the PMR for visitors (Figure 4.14). Each volume introduces a different aspect of the local fisheries culture landscape and allow visitors to learn about its associated activities. By situating the volumes on either side of the extended breakwater wall, visitors will have a chance to occupy the interface between land and water.

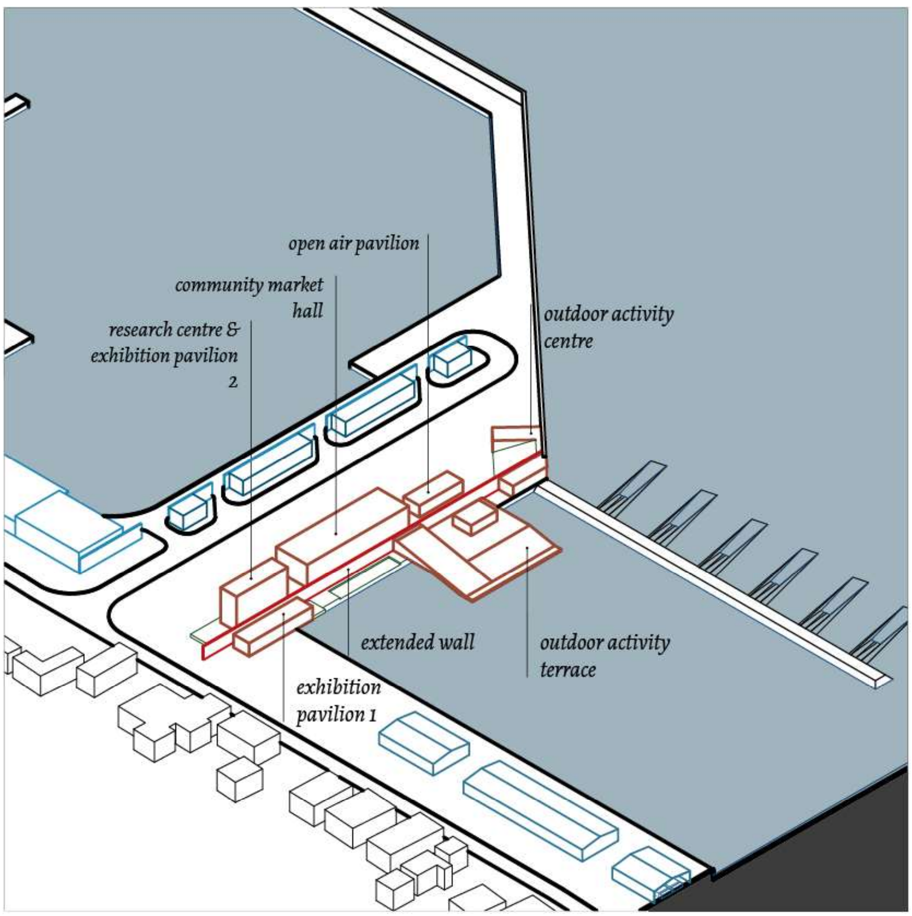


Figure 4.14 - The main structures of the Learning Market Centre.


16
12
13
14
8
3
2
1
4
7
15
5
6

01 Exhibition Pavilion with Observation Terrace

02 Exhibition Pavilion with Research Centre

03 Market Hall with Community Kitchen

04 Market Terrace

05 Festival Terrace

06 Outdoor Activity Terrace

07 Outdoor Activity Centre Service Shed

08 Open-air Exhibition Stage

09 Market Amphitheatre

10 Outdoor Activity Centre Reception

11 Site Tour Slip

12 Market Street Units

13 Seasonal Market Spaces

14 Sunken Plaza

15 Oyster Bed

16 Artisanal Production Facilities

Figure 4.15 - Siteplan for the Learning Market Centre

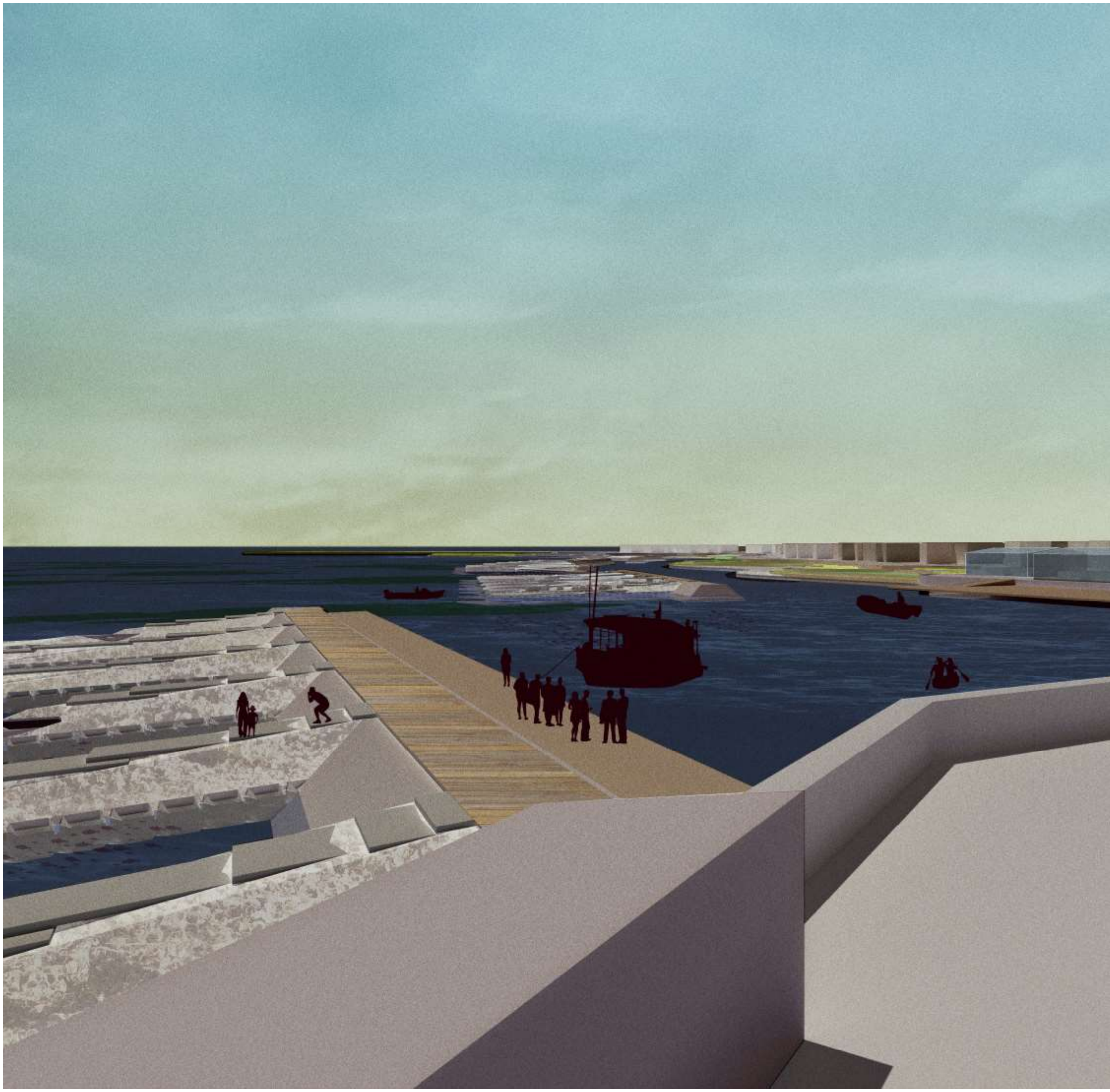
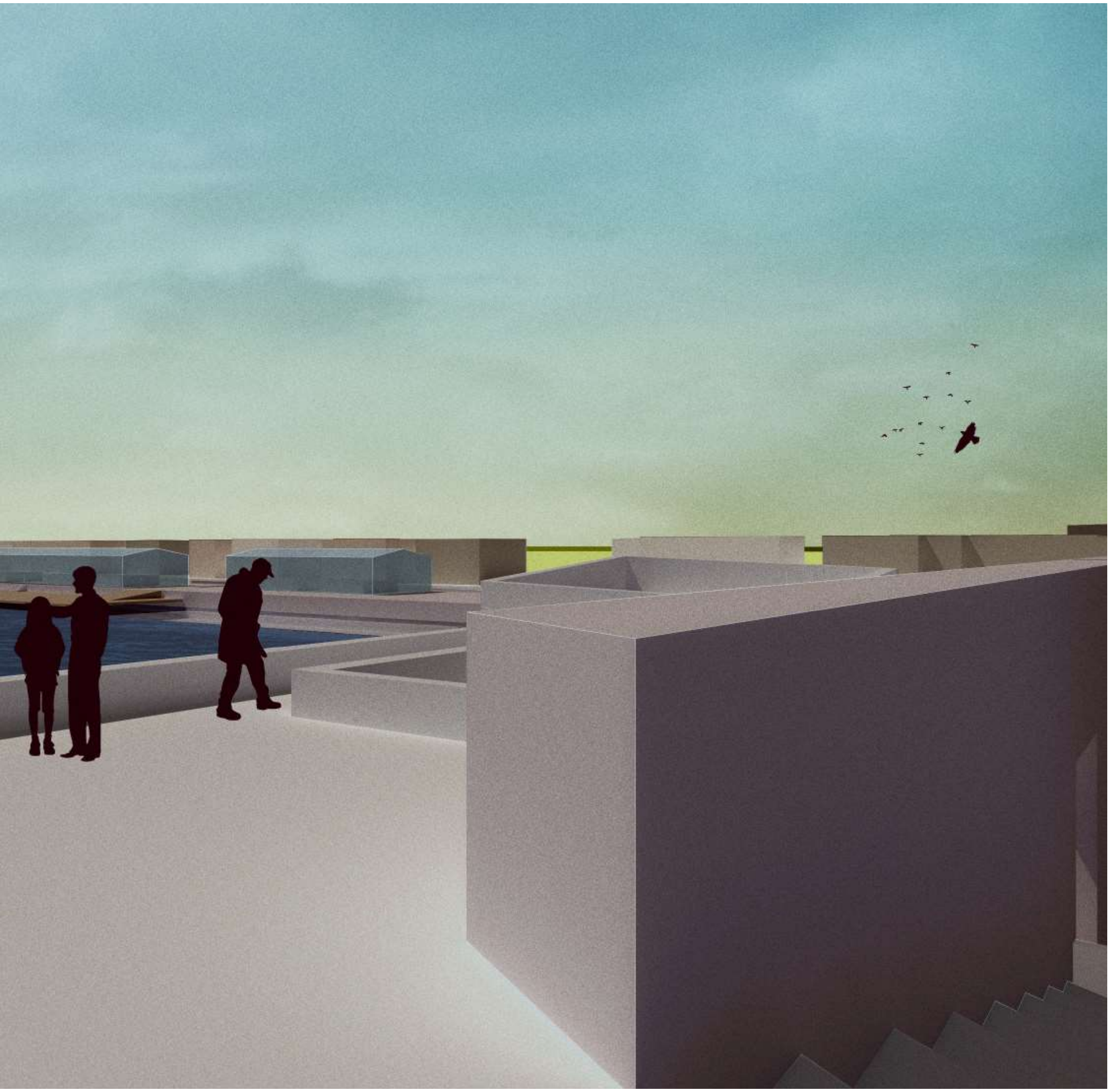


Figure 4.16 - Upper-level wall promenade overlooking the shoreline park



In conjunction with the main Learning Market complex, an additional market street consisting of permanent shops and eateries that feature local marine food products will help to activate the site even outside of museum and market hours (Figure 4.15). These businesses may also be supported by artisanal producers with processing facilities located adjacent to the market.

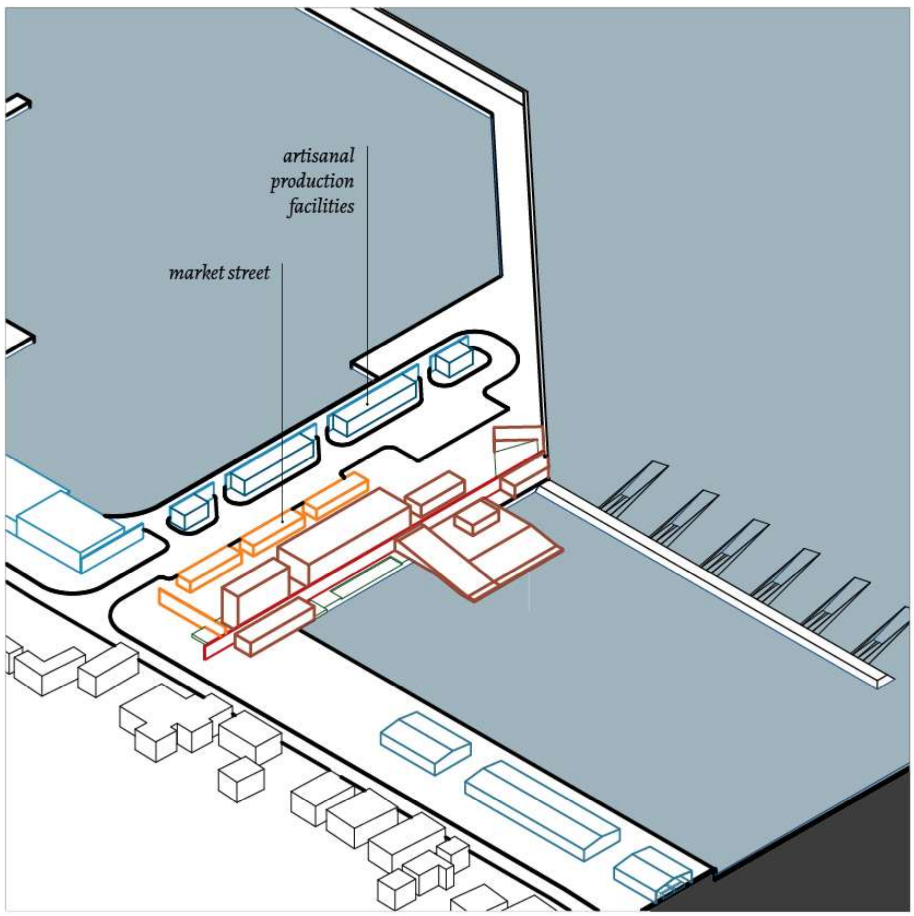


Figure 4.17 - Market street parallel to Learning Market Centre.

Furthermore, a number of open-air terraces and structures (Figure 4.16) will serve as leisure spaces for both visitors and the local community. These spaces may be adapted to accomodate larger crowds and temporary market stalls during seasonal festivals or they can be recreational public spaces that allow occupants to observe and engage with the site. This allows the PMR visitors an opportunity to gain a better understanding of both the natural and human production activities that allow a small community like Oma to thrive.

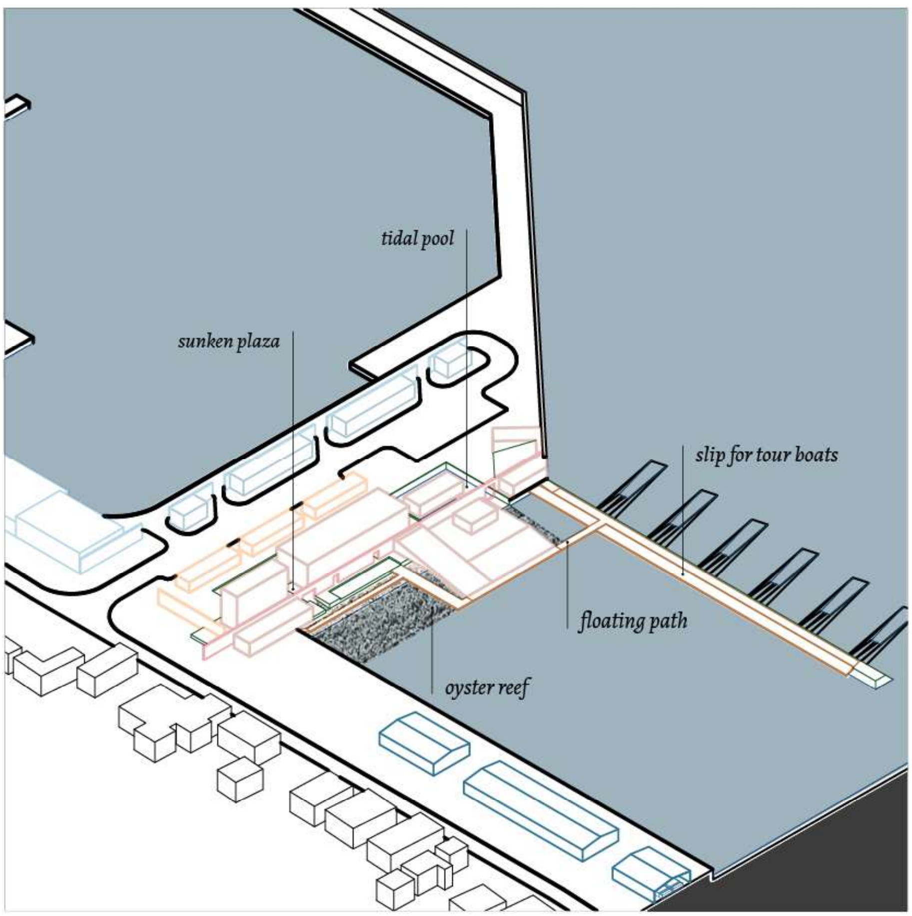
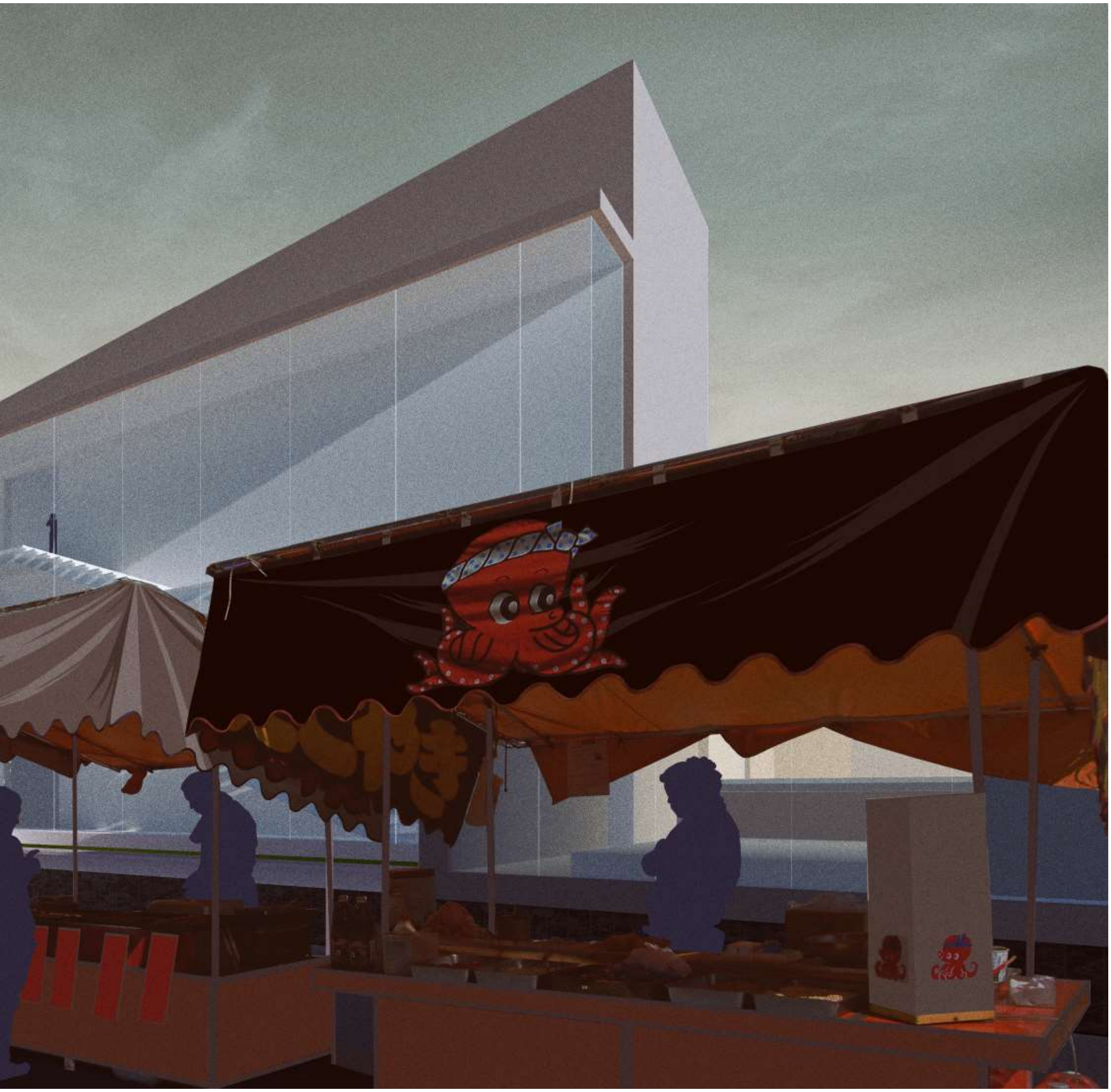
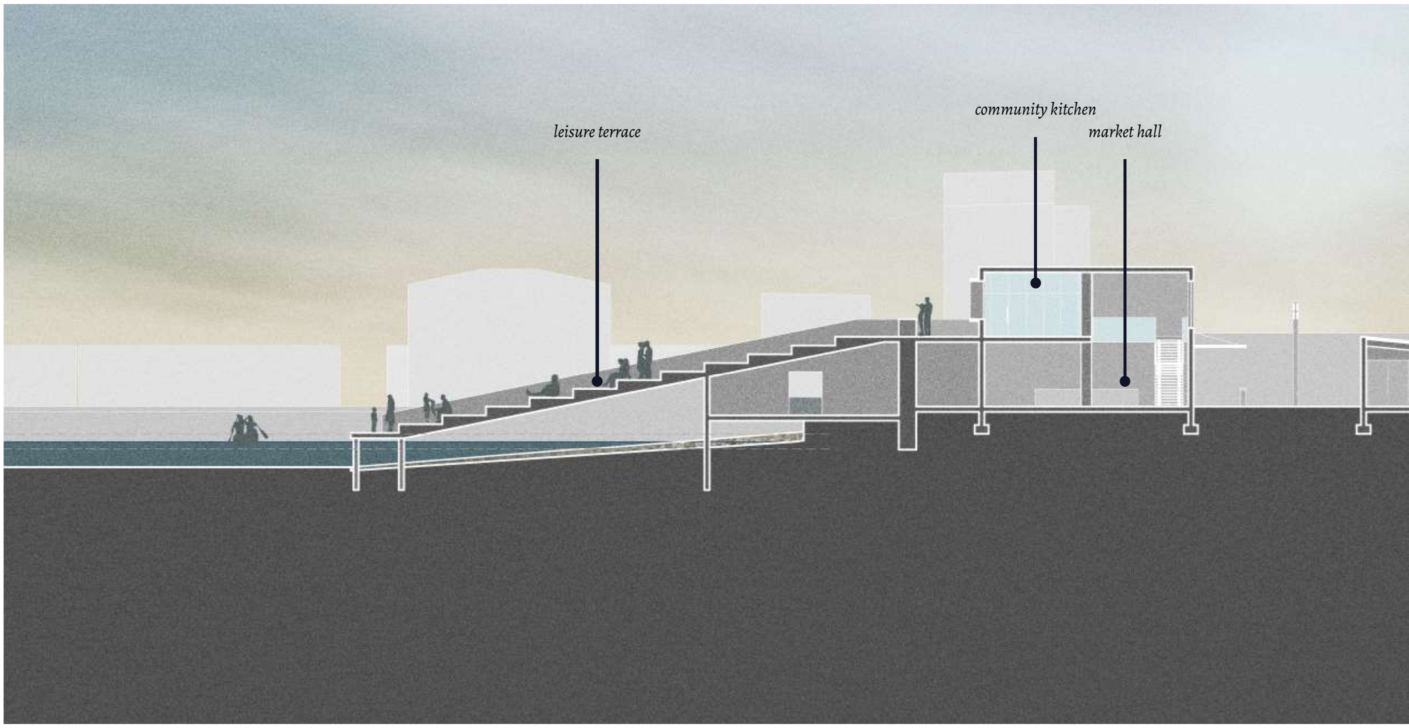


Figure 4.18 - Outdoor and landscape features of the Learning Market Centre.

Figure 4.19 - The outdoor market street viewed from the entrance to the PMR. The buildings of the learning market centre sit in the background.




sunken plaza


leisure terrace
community kitchen
market hall

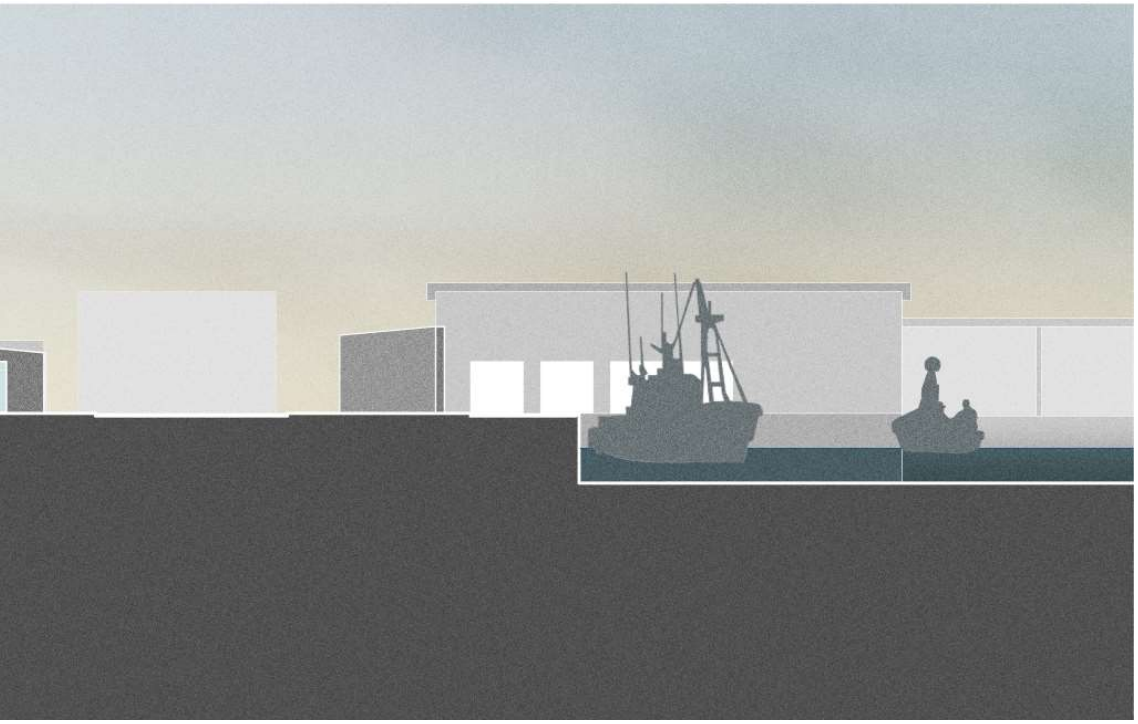


Figure 4.20 - The sunken plaza penetrates through the extended wall to expose visitors to the oyster bed on the other side.

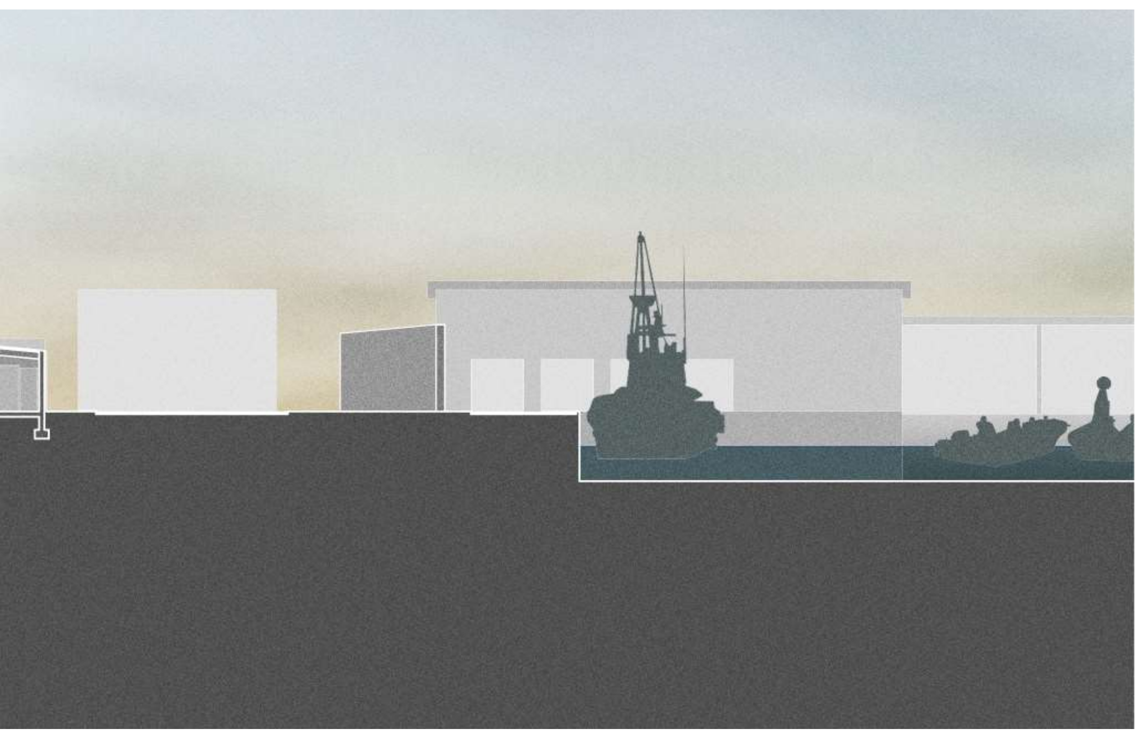


Figure 4.21 - A community kitchen overlooks the market hall while a sloping outdoor terrace provides visitors a space to observe the activities on the site.

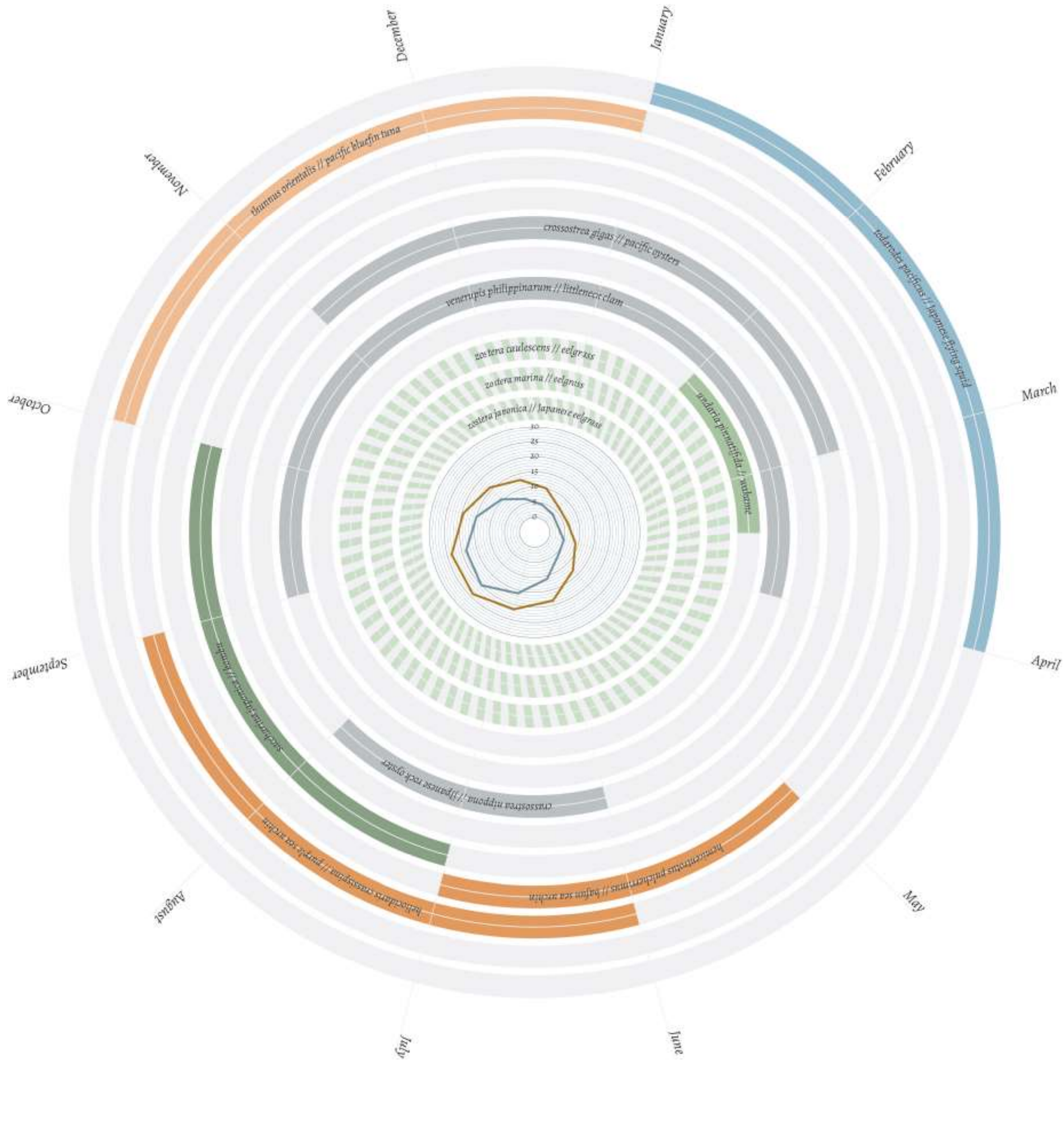


Figure 4.22 - Seasonal harvesting schedule; The centre of the diagram shows the range of water termperatures throughout the year.

Extended Production Activities

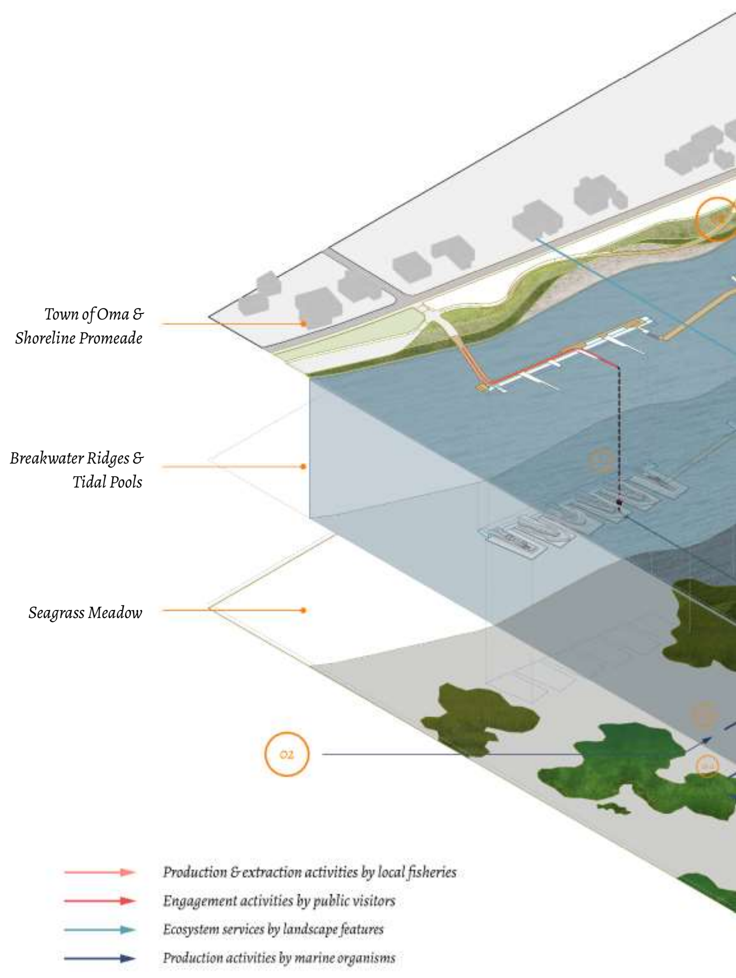
Currently, the fisheries industry of Oma is reliant mostly upon the extraction of Bluefin tuna (*Thynnus orientalis*) and Pacific Flying Squid (*Todarodes pacificus*). As an economic development tool, the PMR is designed to reduce the town's dependence on upper trophic level marine species and provide additional revenue derived from the harvesting of alternative high-value seafood products which can be produced sustainably by the enhanced landscape. Additional harvesting activities would occur during times of the year when the fisheries industry is currently less active, so that engagement with the site by the local community can be extended (Figure 4.22). Maintenance of the kelp farm, seagrass meadow and shellfish farms would be ongoing throughout the year. Extended engagement and presence at the PMR site would help to ensure sufficient administrative oversight and that regional fisheries regulations are properly enforced.

Syntrophic Systems

The Productive Marine Refuge of Oma is designed to support the cultivation of a variety of marine species—not only as seafood products for human consumption, but also for the enhancement of biodiversity in regional waters and long term ecological development of the Shimokita peninsula. It envisions a syntrophic system of mariculture that depends on the multi-trophic relationships between different species within the marine food web at the site, resulting in a more sustainable system of seafood production while maintaining optimal environments for the rehabilitation of marine populations (Figure 4.23).

Targeted species are curated based on both their commercial value as well as their ecological value. The selection process requires examination at multiple scale and takes into consideration the ecosystem services they provide for other species as well as the larger, regional landscape. As such, it is important to examine the circulation and interactions of these species as material flows and energy exchanges within the site. This analysis encompasses more than the just harvest and consumption of marine species by human actors. It also includes an understanding of their full life cycles prior to extraction and even extends into their "death cycles" as by-products of consumption.

This syntrophic system of production is an exercise in productive stewardship, where interdependencies between different species are vital to the long term success of the programme. Creating and intensifying the opportunities for interactions between multiple production processes would further enhance the productivity of the system. By engaging with a wider variety of species, it reduces the ecological stresses placed upon any singular species, while reducing the risk of large scale fisheries and oceans system failure.



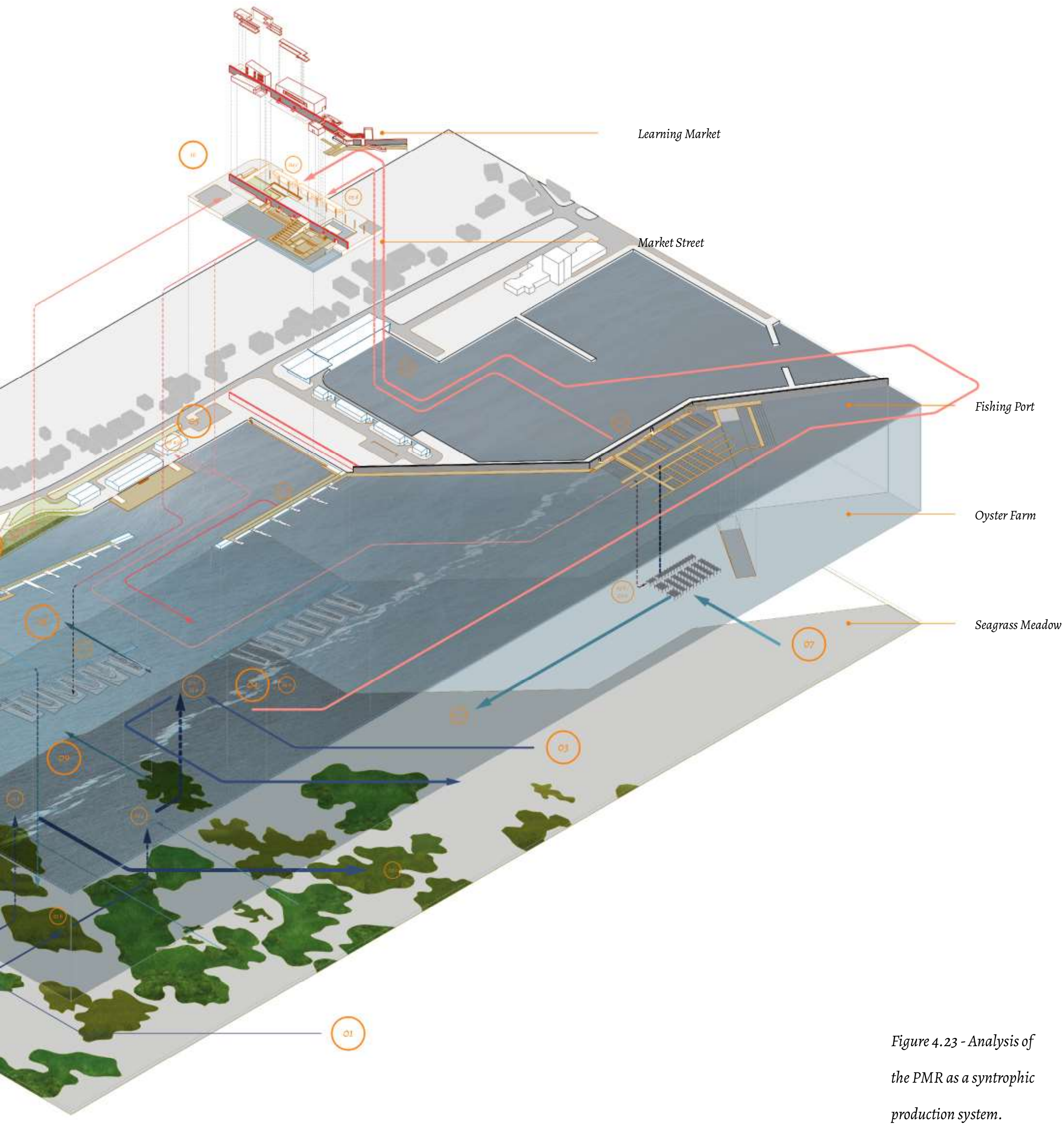


Figure 4.23 - Analysis of the PMR as a syntrophic production system.

01: A habitat for native species

01a: Native coastal species spawn in the seagrass meadow, which provide shelter against their predators.

01b: The seagrass meadow provides a food source comprising of marine vegetation, phytoplankton, crustaceans and etc. for juvenile fish species as they mature.

01c: As the fish mature and grow in size, they occupy higher trophic level positions and begin to consume smaller fish species in the same habitat.

01d: Eventually, these fish also become a food source for humans and other upper trophic level species.

02: A refuge for regional species

02a: Open-water fish species migrate to near-shore waters to utilize the seagrass meadow as spawning waters.

02b: Limitations on fishing activities within the bounds of the PMR site along with an abundance of available food create improved survival conditions for these juvenile fish.

02c: With improved environmental conditions, an increased population of mature fish can migrate to surrounding waters and increase biomass volumes in regional waters.

03: A feeding station for migratory species

03a: Migratory apex predator species, such as Bluefin tunas, takes advantage of the enriched coastal waters of the PMR and utilize the site as improved feeding stations within the region.

04: Artisanal fish harvesting

04a: Increased biomass recruitment to the site as a result of improved habitat conditions help to establish more fertile fishing waters for local fisheries. This gives a competitive advantage to the small-scale fisheries that operate within the PMR site against the industrialised fishing vessels that operate in open waters. In addition, the slower extraction rates of small-scale fisheries help to prevent overfishing.

04b: Fish are brought back to the port with most being processed for local consumption while some will be distributed to major urban markets as regional artisanal products. Enhanced fishing conditions in local waters will also support secondary fisheries activities in value-added processing of seafood harvests.

04c: By attracting public visitors to the site as a consumption destination, the learning market centre helps to limit the metabolic rift and reduce the uneven transfer of organic materials and energies from local waters to faraway regions.

05: Open-system mariculture

05a: Oysters (and other shellfish species) are spawned in local nurseries under controlled conditions.

05b: Once oyster larvae mature into spats, they are transferred to near-shore waters and set out on ropes and cages to mature. Once set into the water, oysters will feed on nutrients brought in by regional and tidal currents, requiring no addition feed input, thereby limiting waste production in the water.

05: Open-system mariculture cont'd

05c: Oysters are harvested upon maturity and distributed for consumption both locally and in major urban markets.

05d: Discarded shells from oysters consumed at the learning market centre can be collected and sorted for reuse in both mariculture and landscape construction.

05e: Oyster shells to be recycled as substrate for oyster spats are sent back to local nurseries.

06: Coastal agriculture

06a: The coastal promenade will comprise of vegetation species that not only help to control shoreline erosion and provide food for coastal fauna, but can also be harvested as food to be consumed by visitors to the learning market. Introducing new food sources to the public would redirect consumption towards species at lower trophic levels that can be more easily produced and reduce demand for marine fauna.

07: Regional currents

07a: The fast-flowing Tsugaru Current brings in nutrient-rich waters to the Shimokita peninsula, but also carry detritus deposited into the water by regional urban settlements.

07b: Filter feeders (ie: oysters), deposit feeders (ie: sea urchins) and marine vegetation (ie: seagrasses) consume and process these materials as food. By removing the pollutants and waste matter from the water, water quality is improved for other marine species in the PMR.

08: Tidal flows

08a: The ebb and flow of tides circulate organic matter (nutrients and waste) in and out of coastal shorelines zones. They also carry and deposit small, lower-trophic-level species into intertidal areas occupied by breakwater ridges. The breakwater ridges provide surfaces for biota to flourish and shelter from larger predators.

09: Wave energy attenuation

09a: The landscape features incorporated into the site help to manage the effects of strong waves brought on by local weather conditions as well as the high speed flow of the Tsugaru Current, and limit their negative impacts on biological processes. Elements such as the seagrass meadow and breakwater ridges provide wave energy attentuation, resulting in calmer waters near the shoreline. This prevents intensified erosion of the shoreline while stabilizing the water for smaller fishing vessels.

In addition, the seagrass meadow restricts resedimentation of seafloor debris, which could limit access to sunlight for marine algae (ie: wakame) and the seagrass themselves. The inclusion of oyster gabions distributed amongst the seagrass meadow further augments this service.

10: Public Engagement

10a: Beyond educational opportunities provided by exhibitions at the learning market centre, visitors can participate in boat tours and explore the site with a guide. They can also conduct their own tours by renting a canoe to travel through near-shore waters. Limited fishing activities at the site will be available depending on seasonal conditions and the success of the site's ecological rehabilitation programme.

10b: Consumption activities at the learning market site also play a role in the construction of landscape elements. Visitors may bring the remaining shells of the seafood they have consumed and deposit them onto the breakwater ridges. Over time, this forms new substrates upon which marine biota can grow.

10c: Visitors can engage with the natural inhabitants of the PMR by taking a walk along the coastal promenade and out onto the breakwater ridges themselves. The tidal pools created by the breakwater ridge structures offer a constantly changing cabinet of curiosities for visitors to explore.

Figure 4.24 - Derelict structures common along the entirety of the town's edge.

The Shoreline Park

Much of the town's shoreline is currently occupied by abandoned fishing boats and underkept storage structures belonging to local fisheries operations (Figure 4.24 & 25). Due to these obstructions, direct access (both physically and visually) to the water is limited. The PMR proposes a clean-up of the shoreline and repurposing the land as a semi-natural coastal promenade to augment visitor's exploration of the site (Figure 4.26).

The shoreline park maintains the community's close relationship with the sea and reinforces its dependence upon the sea as a source of livelihood. However, it augments that relationship by providing opportunities for alternative fisheries' activities that not only provides additional sources of food and revenue, but also enhances biomass recruitment and ecological productivity through these human activities in the landscape. The redeveloped shoreline will be composed of a set of descending, cultivated terraces planted with edible coastal halophytes (Figure 4.27).

Figure 4.25 - One of many abandoned fishing vessels found along Oma's coastline.

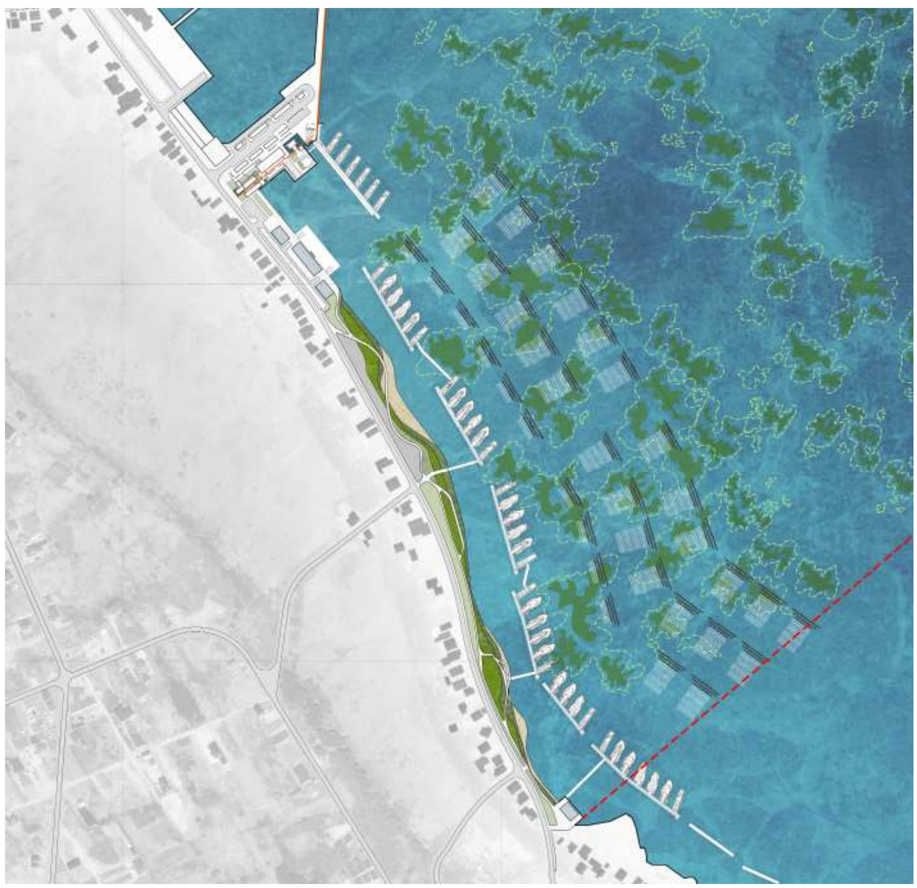


Figure 4.26 - Siteplan for the shoreline park.

These plants can be distributed to both local and extended regional consumers as alternative, sustainably harvested marine food products. Furthermore, these plants and accompanying intertidal oyster beds will help to stabilize the shoreline against erosion by waves.

In addition to its function as a cultivation site, the shoreline park is also a recreational space for public visitors. A meandering path that intersects with the various cultivated terraces guides visitors through shoreline. Extended boardwalks lead visitors out onto the the breakwater ridges, where a series of tidal pools that function as cabinets of curiosities reveal different regional marine fauna to visitors. These tidal pools increase the visibility and accessibility of marine species to consumers, highlighting the dual role of marine environments as both habitats and fisheries landscapes. The anchor units used as retaining blocks for the oyster shells on the ridge also provide shelter for smaller fish and create new surfaces for the growth of marine biota.

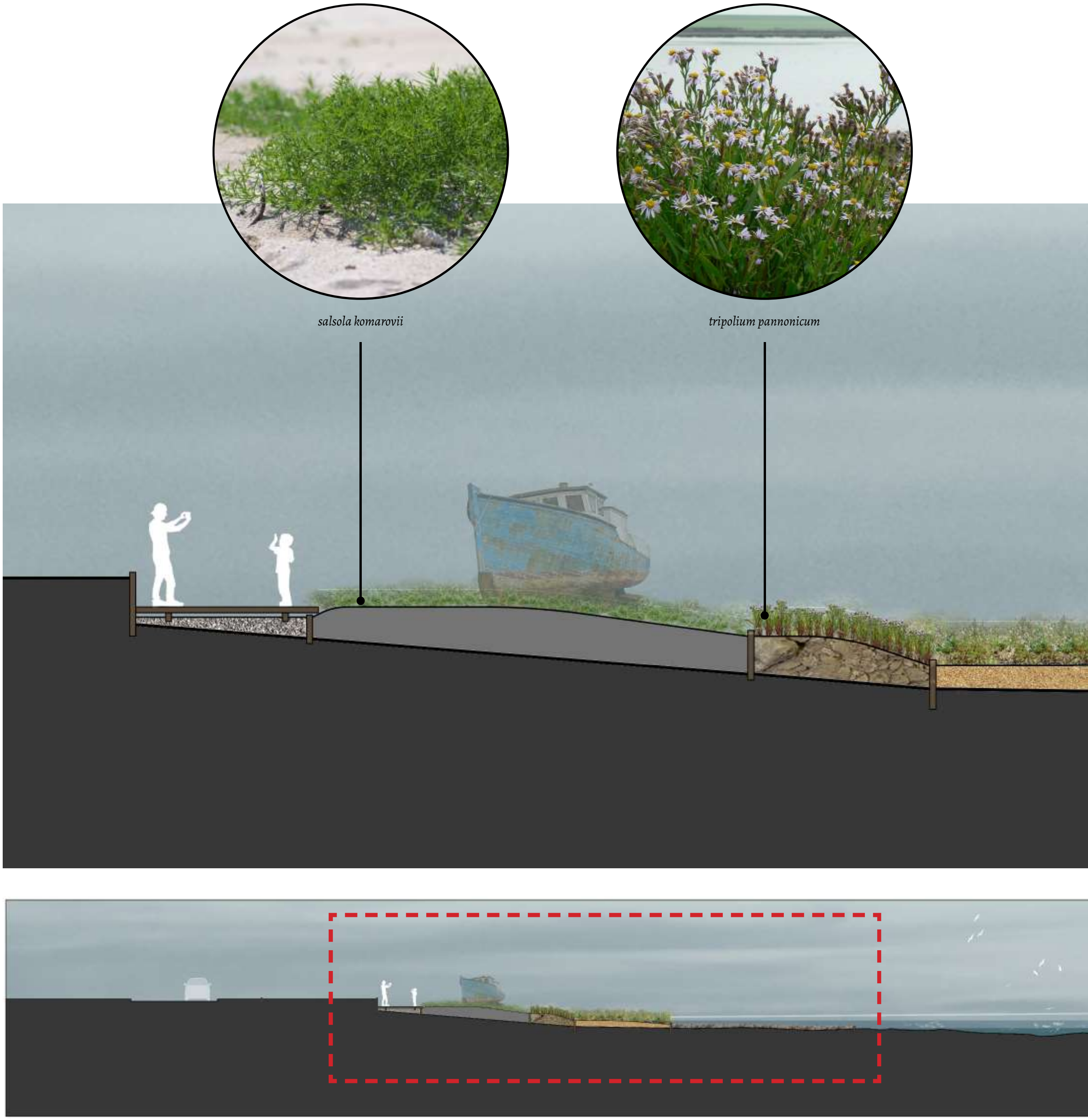
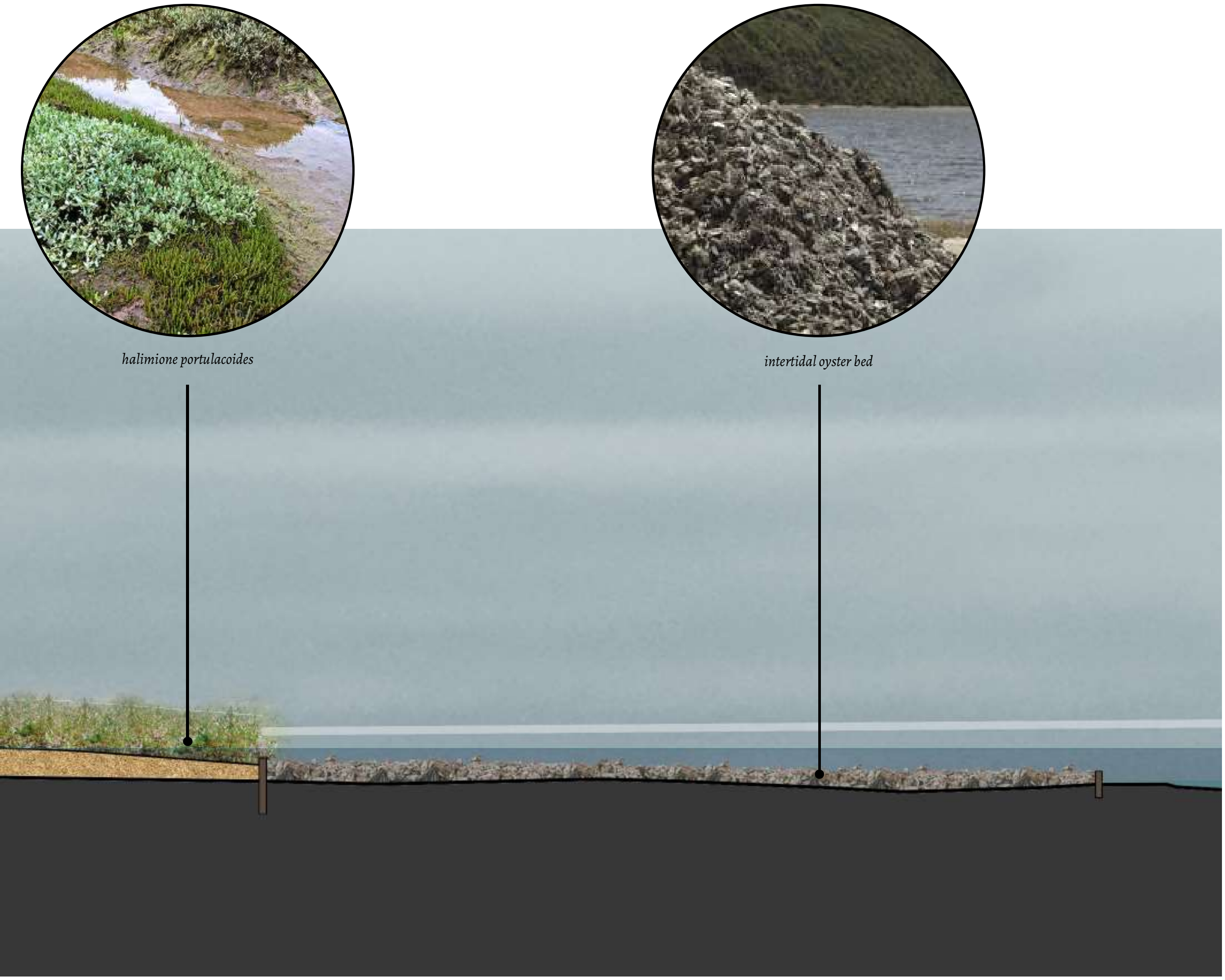
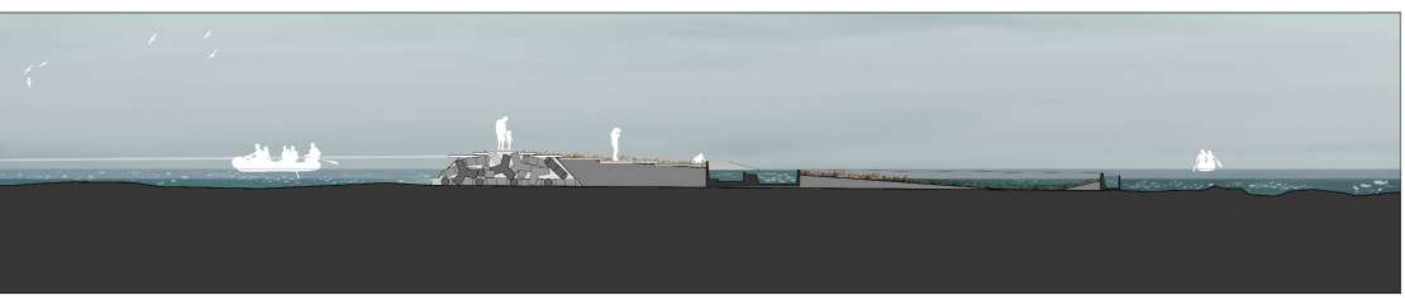


Figure 4.27 - Section through shoreline park.





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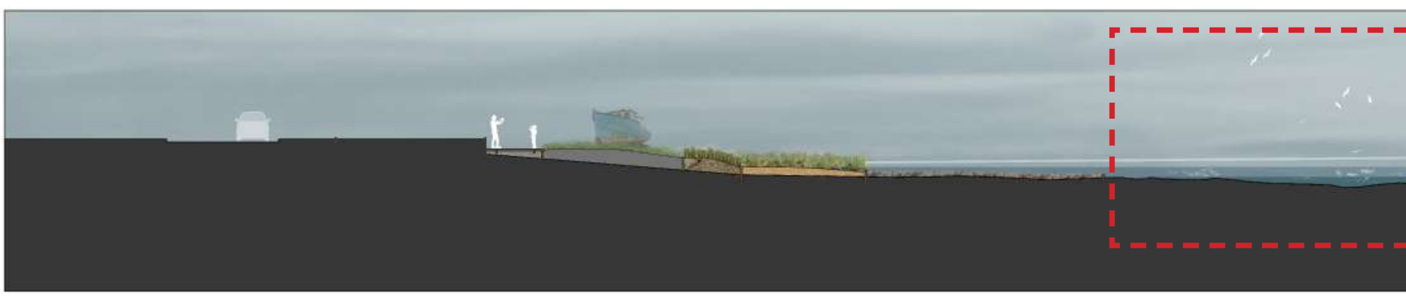
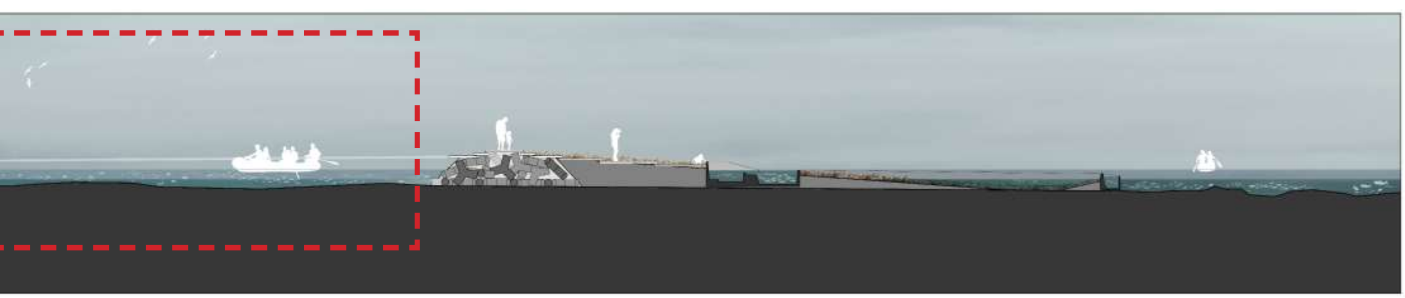
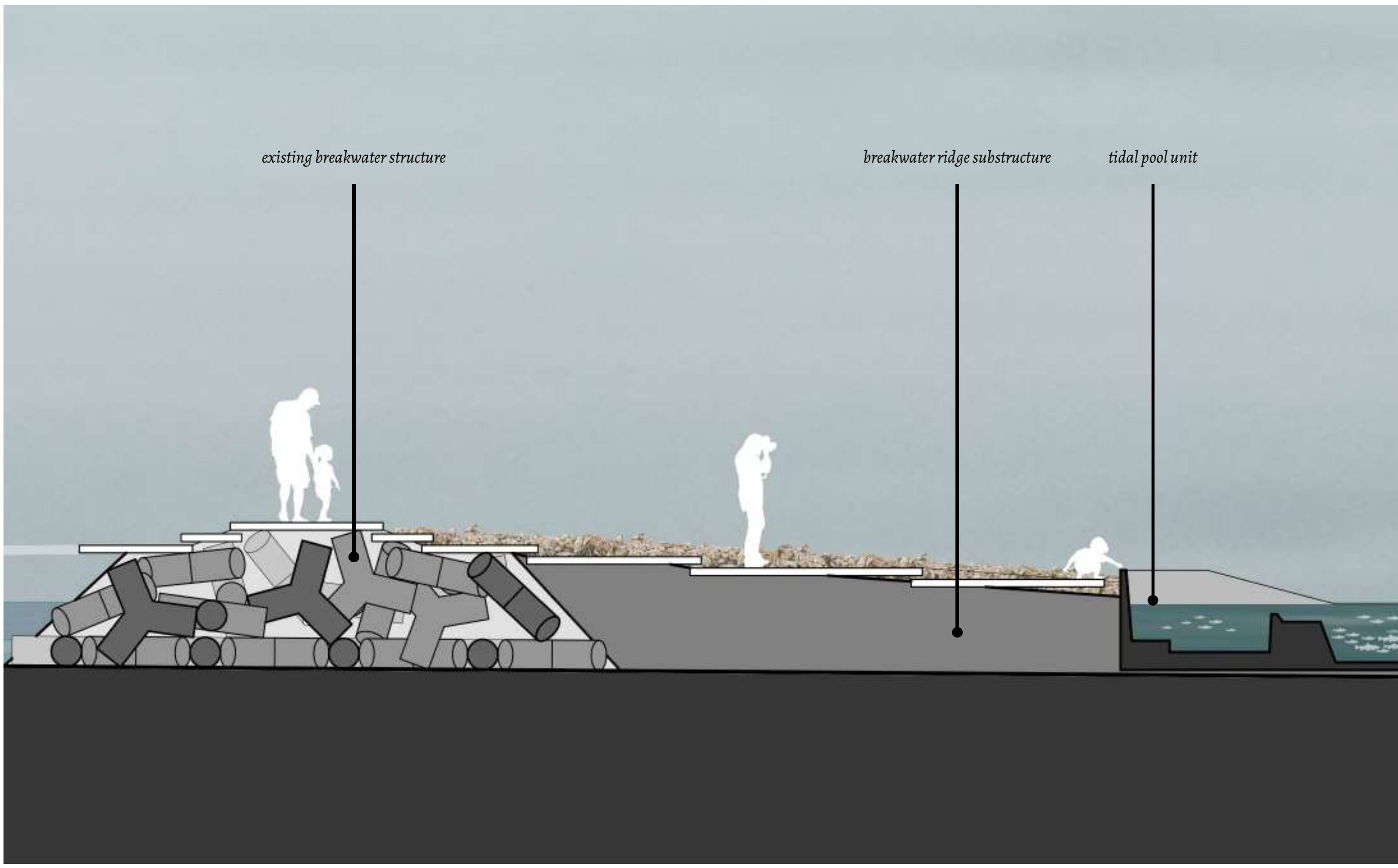
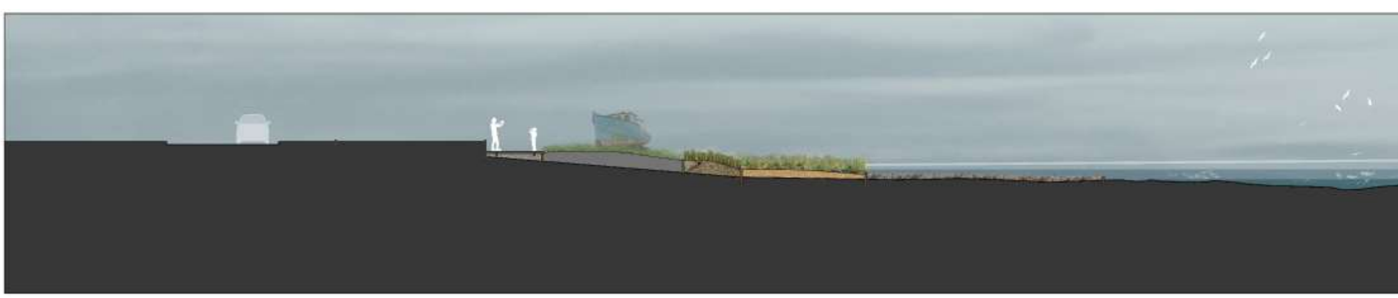





existing breakwater structure
breakwater ridge substructure
tidal pool unit




recycled oyster shells
anchor pool unit

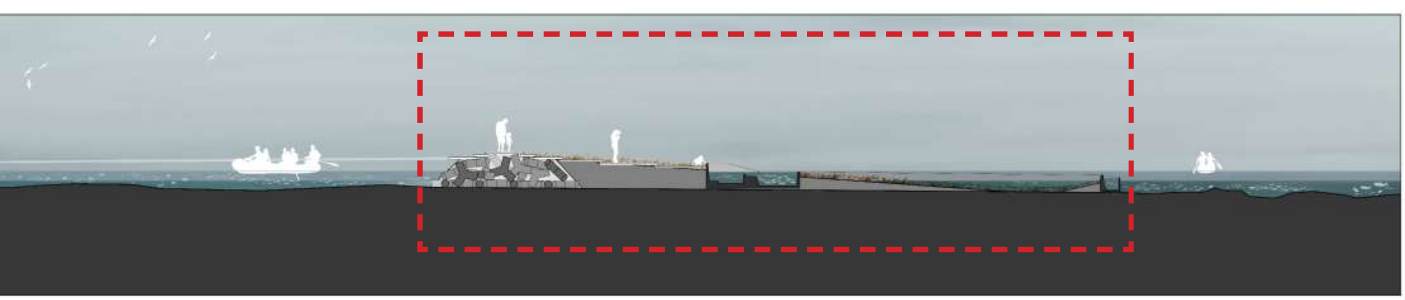


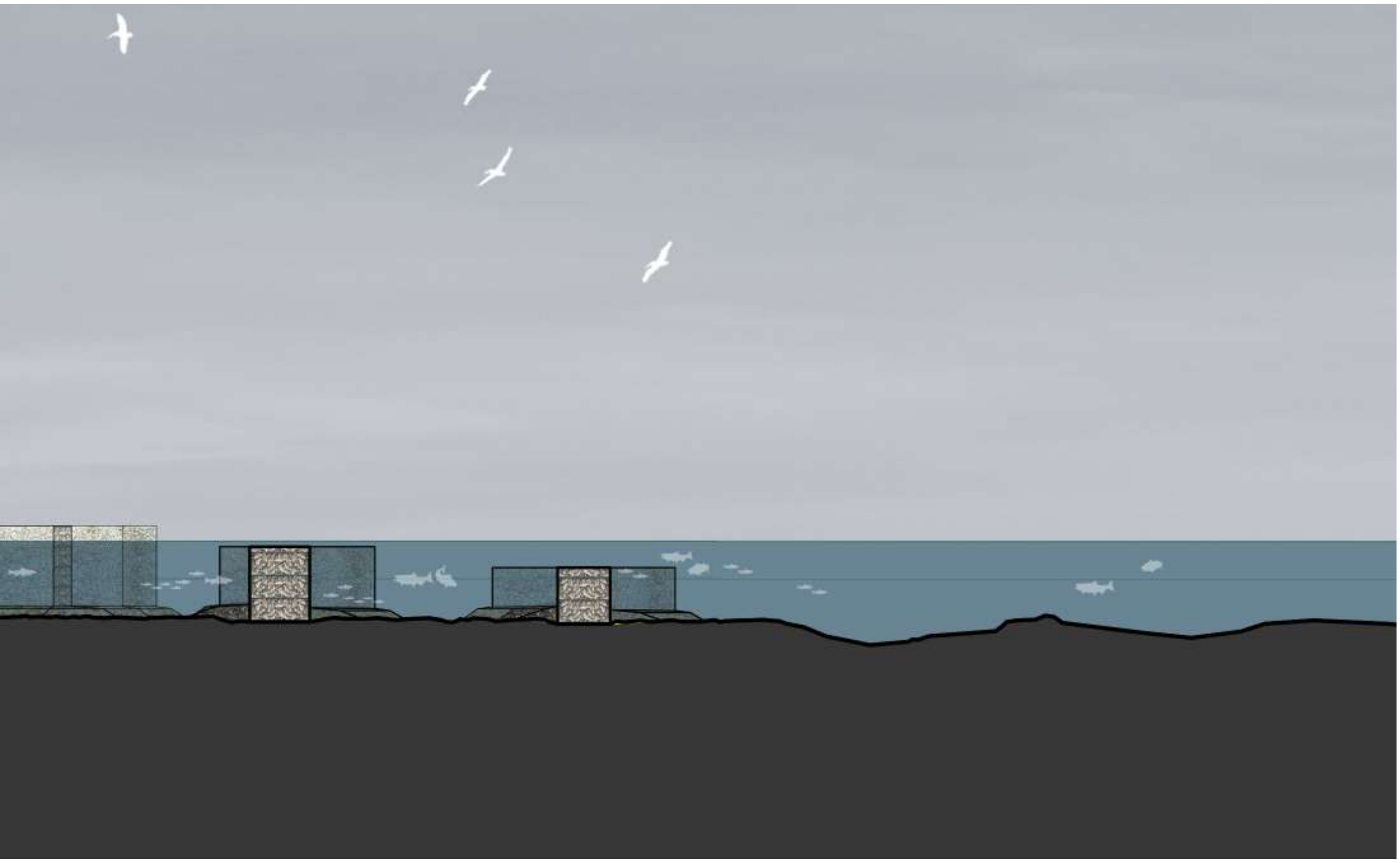
Figure 4.28 - The shoreline promenade provides an opportunity to engage with coastal flora and fauna, as well as to observe fisheries worker at sea.

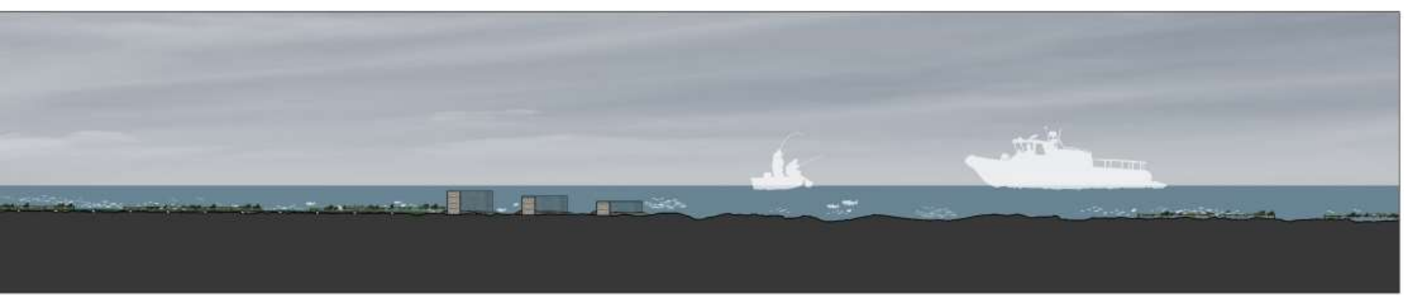
The Seagrass Meadow & Wakame Farm

The establishment of a seagrass meadow addresses the need to enhance the landscape's primary production capacity and lower-trophic level biomass measures in order to improve overall ecosystem biodiversity. Seagrasses provide protection

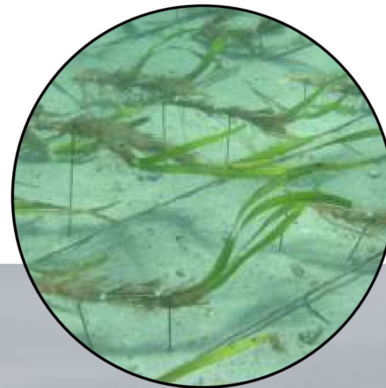
Figure 4.29 - Section through seagrass meadow.

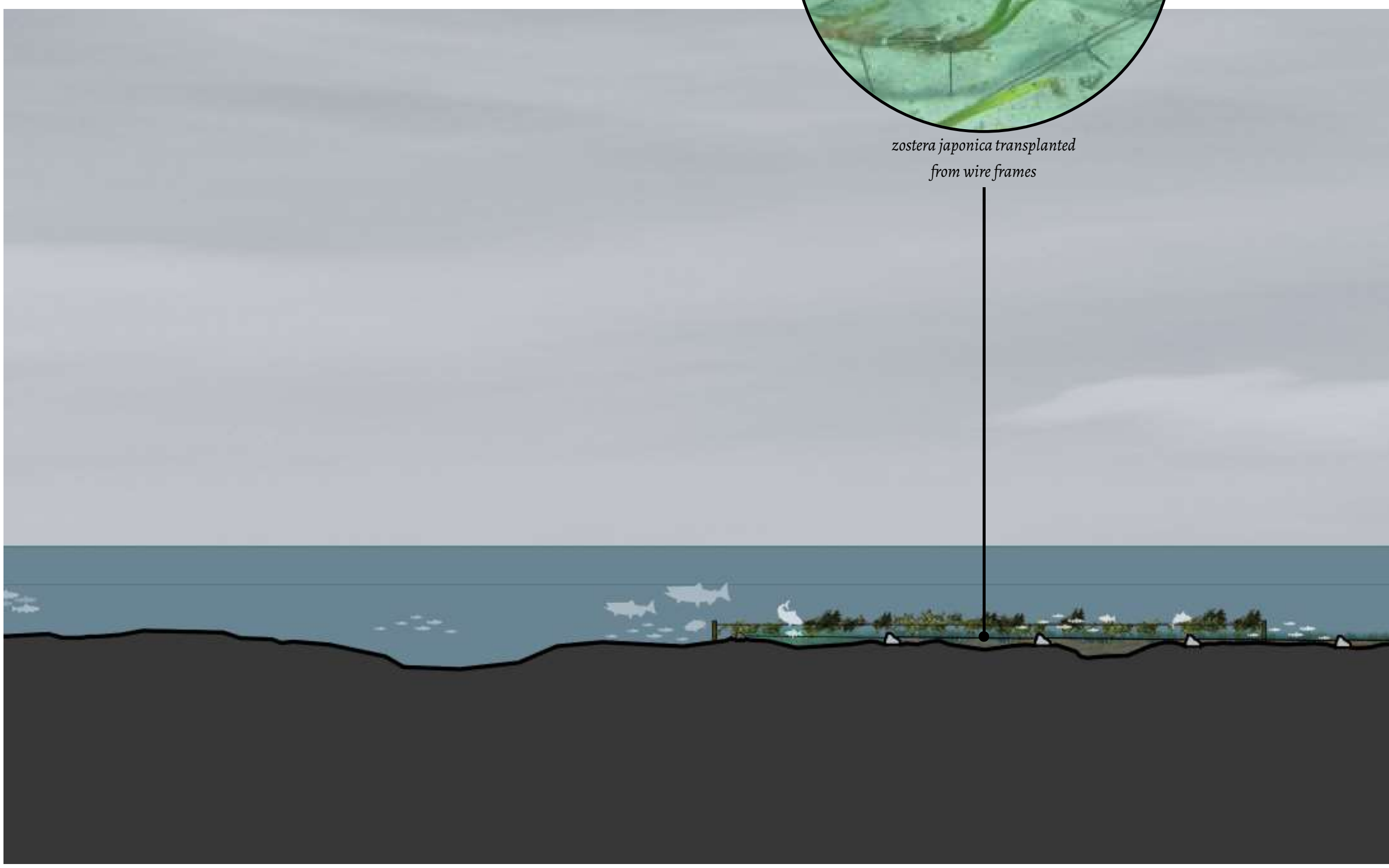
from predators for smaller marine species and host a wide variety of crustaceans that are prey for these fish[11]. As a result, they are important nursery habitats and foraging grounds for species from a range of trophic levels. In addition, the many ecosystem services (such as seabed erosion control and wave energy attenuation) provided by

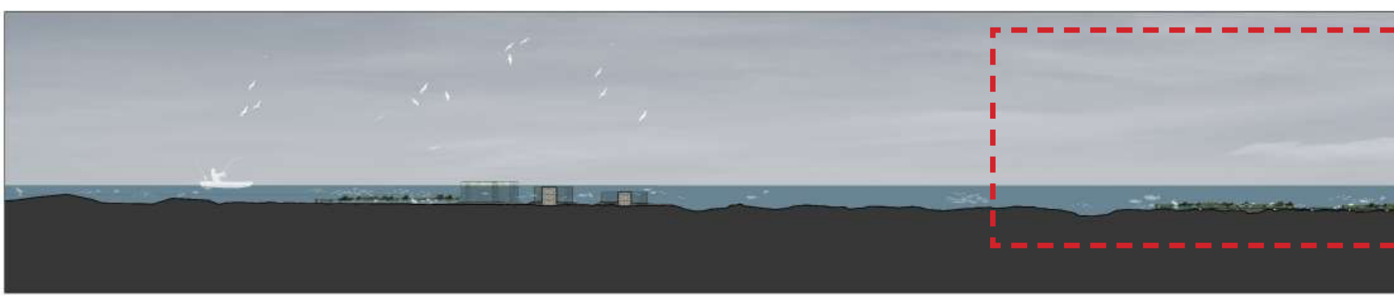




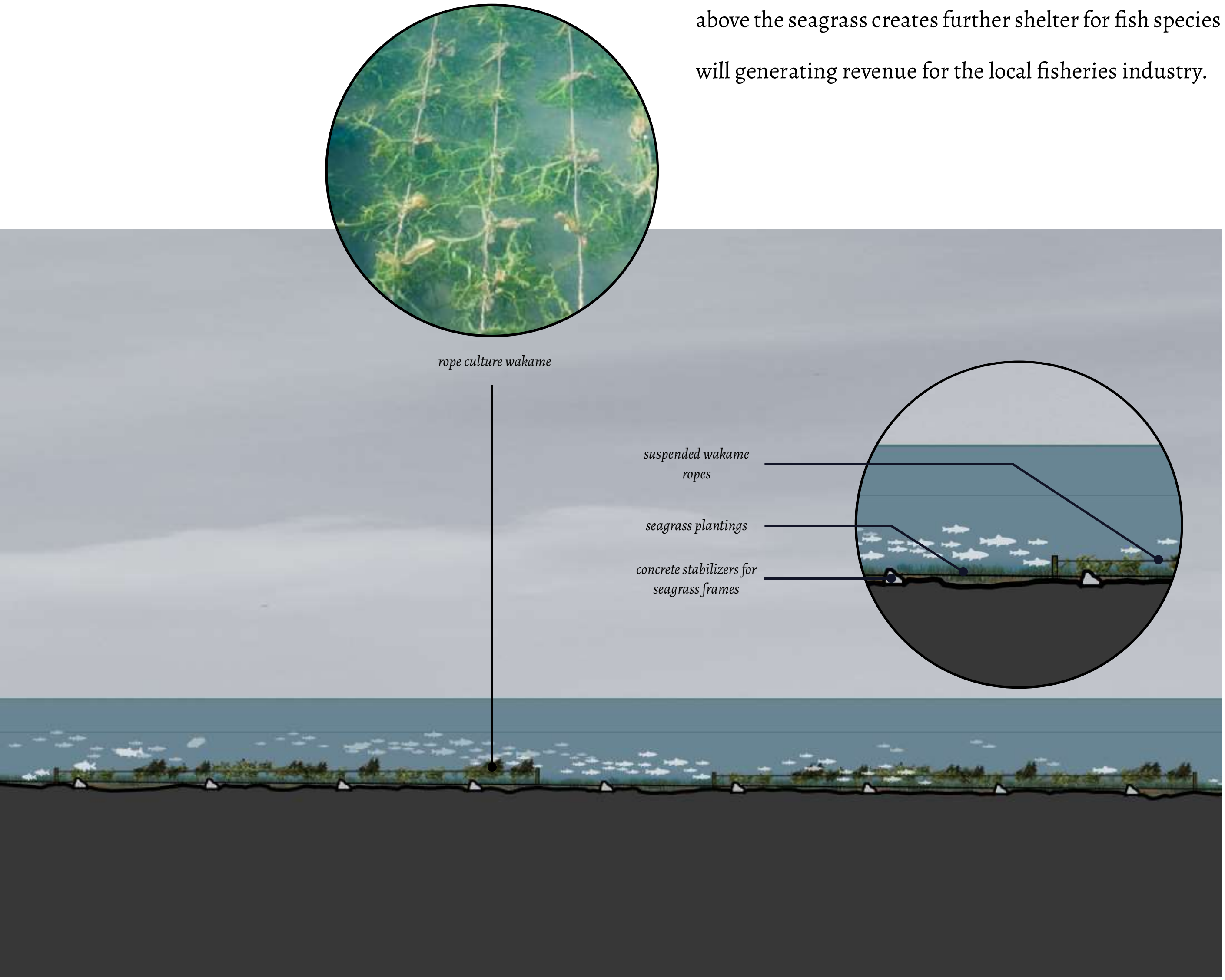
seagrass meadows will enable the site to develop with greater stability and reduce the risk of catastrophic failure in the event of a natural disaster. A wakame farm established

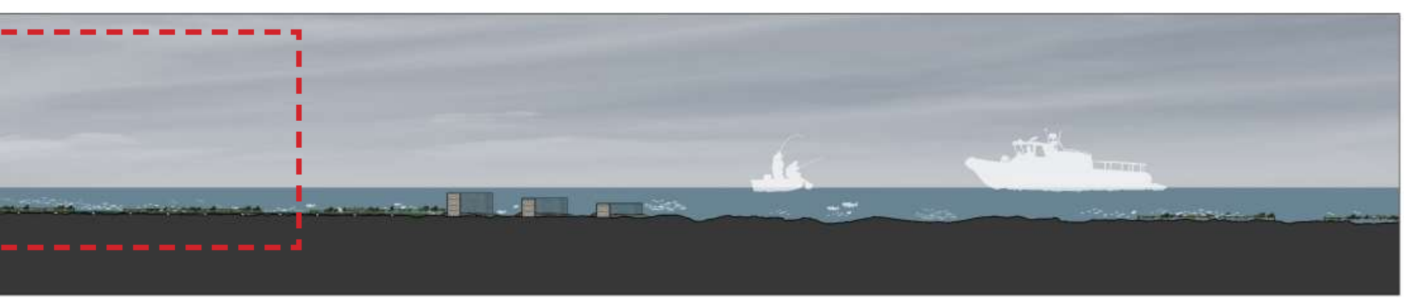


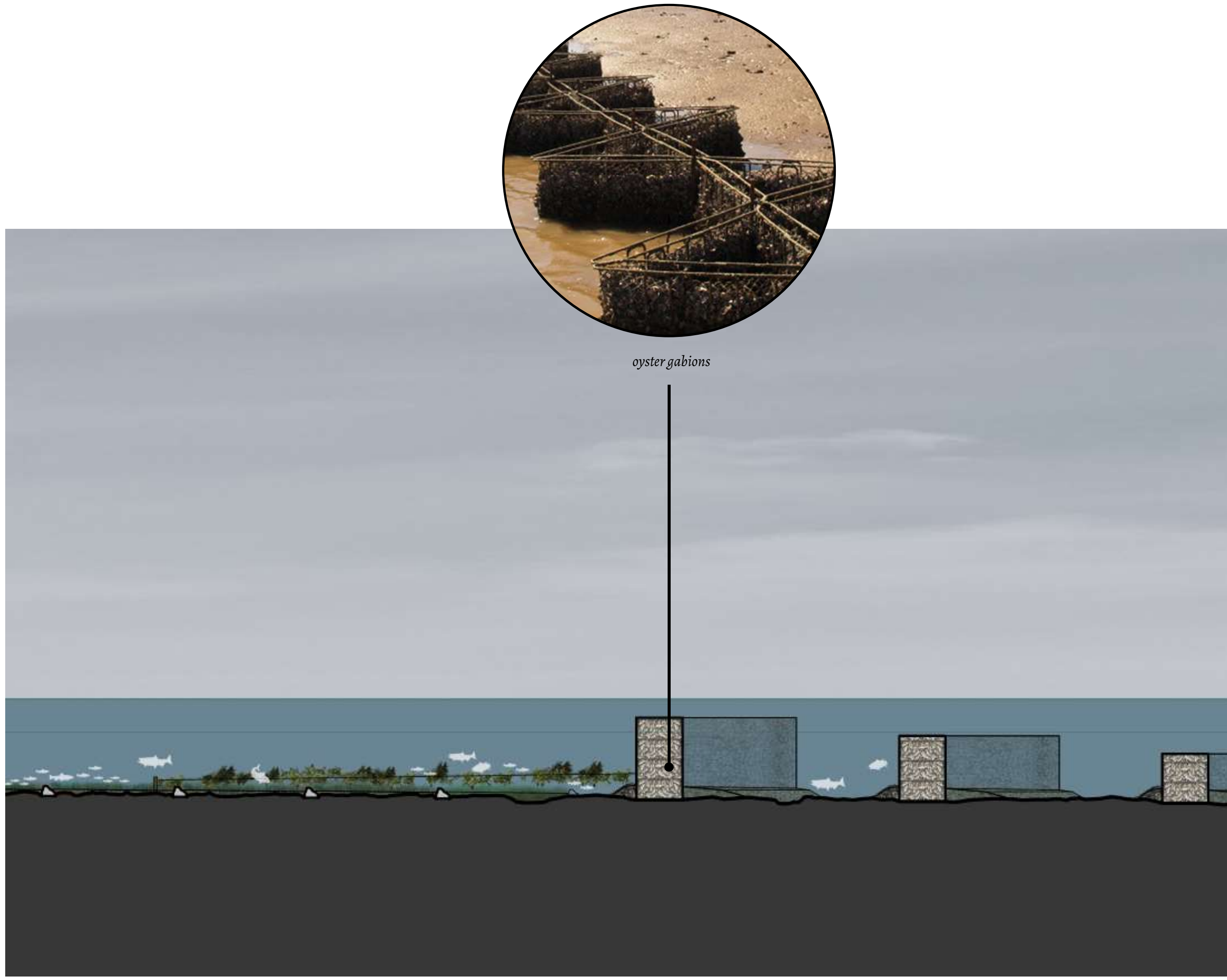


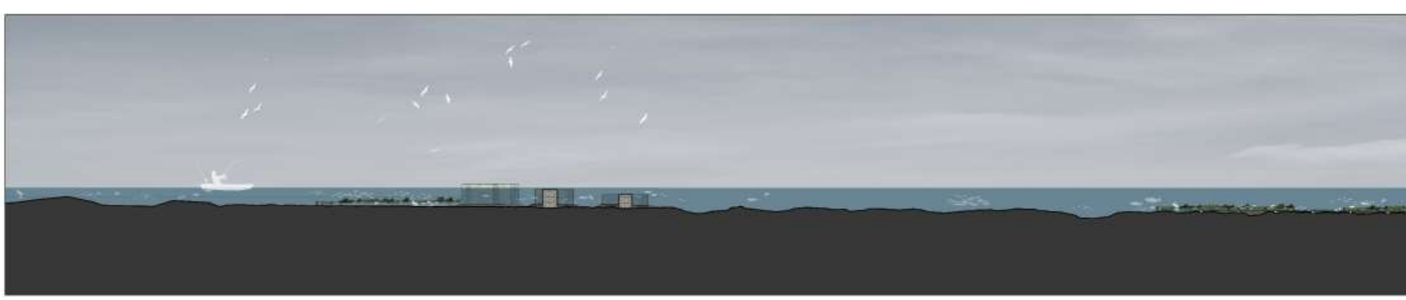


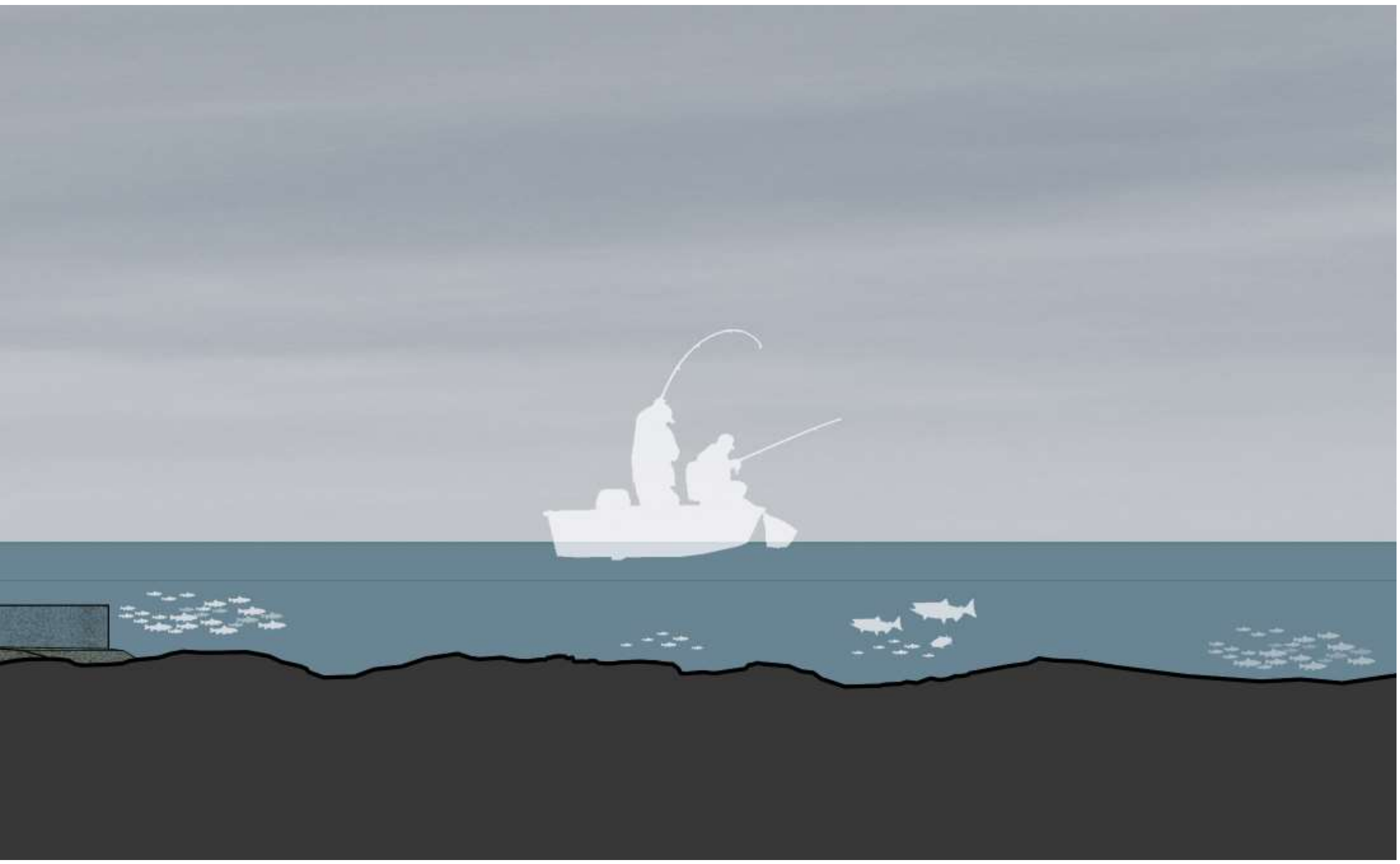
above the seagrass creates further shelter for fish species will generating revenue for the local fisheries industry.






oyster gabions





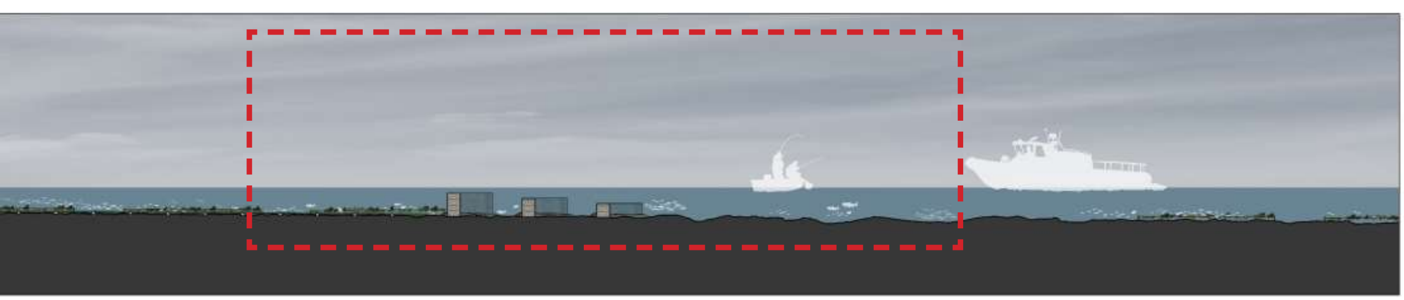
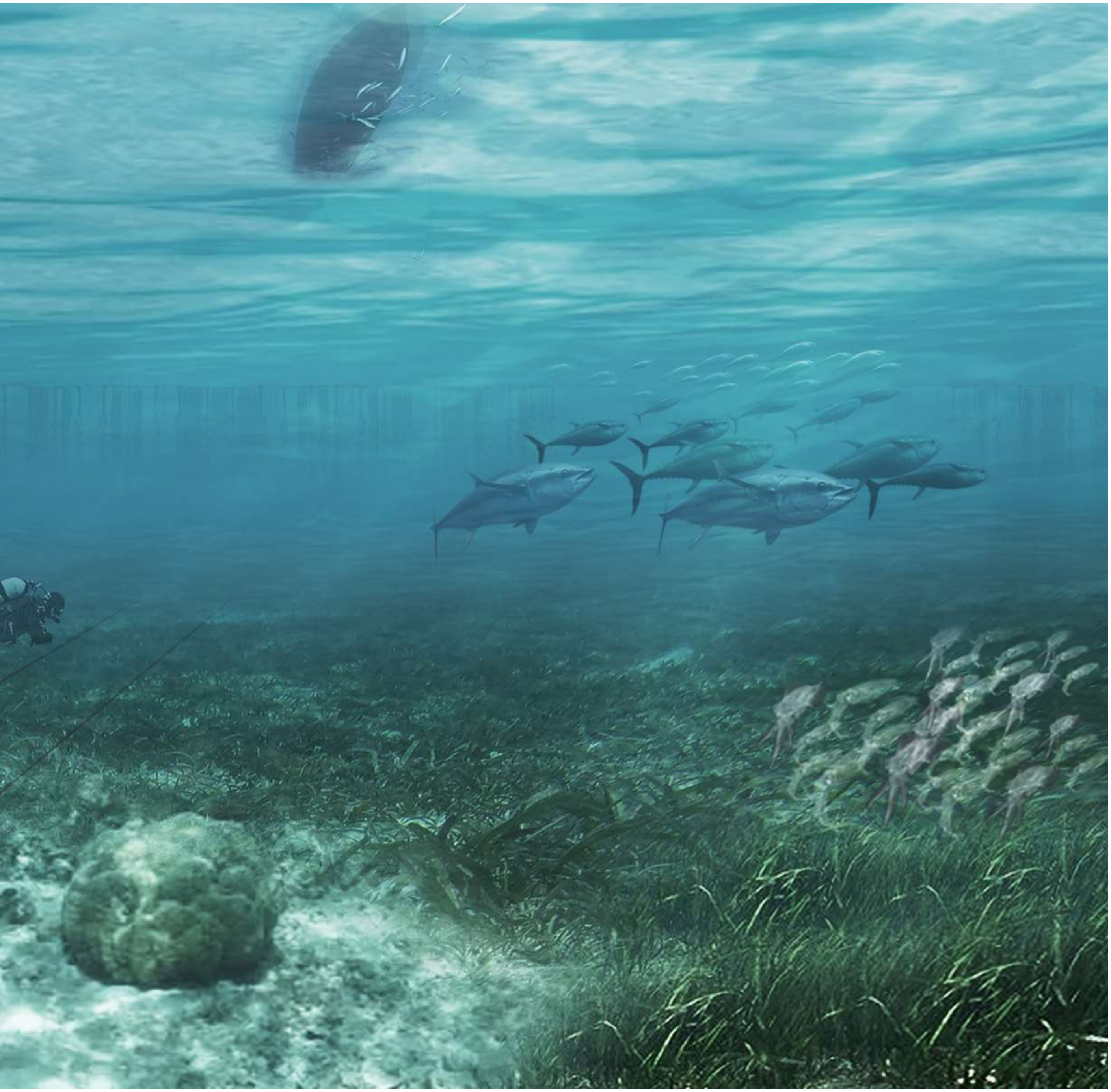


Figure 4.30 - The seagrass meadow as foraging grounds and habitat for many fish species allows for greater biodiversity within the Shimokita region. The increased fish populations makes for more fertile fishing waters for local fisheries industries.



Situated further out from the shore, the seagrass meadow (Figure 4.29) services as a habitat for lower trophic level species as well as nursery waters for juvenile species, thereby promoting greater marine biodiversity. Grown in a series of patches distributed across the site, the seagrass meadow will expand over time, and require ongoing maintenance and trimming back to preserve edge conditions that are vital for prey species seeking shelter from larger predators. The areas removed can be alternatively replaced with rope culture wakame elevated above the seafloor. The layering of seagrass and suspended wakame ropes create a variety of shelter conditions for fish. Additional revenue for the fisheries community can be generated through the seasonal harvesting of wakame, while the regular presence of local fisheries workers in these near shore waters will help to maintain administrative control over the site.

Oyster gabions placed in the water not only provides wave energy attenuation for the seagrass meadow, but also helps to limit re-sedimentation and control the movement of suspended particles which could impede the growth of seagrass as a result of restricted sunlight access. The gabions can be constructed out of recycled oyster shells with live spat culture to establish new oyster reefs in the water. These reefs will provide water quality control for the meadow, ensuring that the seagrass meadow and its fish inhabitants have the optimal conditions necessary to thrive.

1m x 4
Saccharina japonica | Ma-Konbu

0.30m
Undaria pinnatifida / Wakame

0.08m
Heliocidaris crassispina/ Kita Murasaki Uni ("Purple Sea Urchin")

0.07m
Hemicentrotus pulcherrimus / Ezo Bafun Uni ("Horse Dung Sea Urchin")

0.15m
Crassostrea gigas / Pacific Oyster

0.04m
Venerupis philippinarum / Japanese Littleneck Clams

Figure 4.31 - A selection of the high-value shellfish and algae cultivated within the PMR.

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Epilogue

5.1 Epilogue

The Bluefin tuna is only one example of the many marine species that have fallen victim to our voracious appetites. Unless urgent changes are made to the way we treat the oceans as a food source, it is without a doubt that other species will continue to meet a similar fate as others before it.

The Productive Marine Refuge that was created as part of this thesis project does not attempt to provide a guide for how to save a singular species, but rather, it sets out to highlight some of the land-use strategies that can be utilized by rural coastal communities to establish sustainable fisheries programmes that can enhance marine ecosystem health. It stresses the need to enhance the primary productivity of marine ecosystem in order to improve biomass recruitment and reduce ecological stresses caused by human activities at sea. The PMR of Oma works with existing regional regulations and fisheries techniques to create a maricultural landscape supported by syntrophic processes and relationships. At the same time, the PMR places equal importance on educating the public about responsible seafood consumption and raising public awareness of its dependence on healthy ocean environments. It achieves this by providing opportunities for direct engagement with marine ecologies and fisheries activities.

The productive conservancy approach to landscape development returns agency to the most vulnerable and affected of stakeholders and empowers them to better protect their environments. If we are to continue to rely on the oceans as a stable food

Figure 5.1 - Winter fishing on the rough seas of the Tsugaru Region.

source, we must employ production and conservation strategies that simultaneously engage with the range of anthropogenic and natural processes that govern the oceans, both within the immediate landscape and the larger regional environment. Only then can we perhaps rebalance the relationship between humans and the sea.

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