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THE SEA VAULT : OFFSHORE ECOTOURISM AQUACULTURE CENTRE AT PULAU BESAR, JOHOR DARUL TAKZIM

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ABSTRACT

Malaysia is one of the major fish consumers globally, with 56.5 kg of fish consumed per person each year, which is higher than the world average fish consumption. High fish consumption and sea pollution affected the number of captured fisheries. Malaysia, at this point, must not rely on captured fisheries as the primary seafood resources. Hence aquaculture is seen as the most suitable way to overcome the issue. However, land aquaculture produced freshwater pollution and resulted in low-quality fisheries. Therefore, this research proposes a sustainable offshore aquaculture centre design in Malaysia to reduce water pollution and increase marine fish produce. The first objective of the research is to identify the type of marine fishes that can increase other marine fish population. The second objective is to determine sustainable aquaculture practices. The third objective is to determine the appropriate research facilities for breeding and production. The whole study was at Pulau Besar, Johor. The research methodology adopted is qualitative research through case studies, interviews, and structured observation. The first finding is that parrotfish identified as important species for breeding to balance the marine ecosystem. The second finding had identified sustainable aquaculture practices such as cage angling, fish breading in its natural habitat, use of natural food for fish feeding. The third finding identified is marine research laboratories like hatchery, experiment, parrotfish sanctuary, which can increase marine fish production.

Keywords: *Aquaculture, ecotourism, offshore, marine fisheries, ecosystem, Pulau Besar, Johor.*

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INTRODUCTION

Aquaculture is defined as the breeding or farming of aquatic life or organisms such as fish, crustaceans and aquatic plants, which implies advanced processes to increase production such as food stock, feeding and protection from predators (Food and Agriculture Organisation of the United Nation (FAO), 1988). Aquaculture in Malaysia began in 1920, predominantly within brackish water, followed by freshwater and marine aquaculture. The cultured species of aquaculture in Malaysia are shellfish, freshwater species and marine finfish (Food and Agriculture Organisation of the United Nation (FAO), 2013). In the 1920s, aquaculture in Malaysia began to develop within the ex-mining pool where carp species such as bighead carp (*Hypophthalmichthys nobilis),* silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idellus)* were bred.

Ten years later, marine shrimp was first introduced in Johor within trapping ponds. In the 1940s and 1950s, blood cockles and freshwater fish were both farmed in the earthen ponds. The 1970s witnessed the significant growth of aquaculture where floating net cage culture of marine fish, mainly the green grouper (Epinephelus coioides), began to be farmed together with the culture of green mussels. This trend continued until the 1990s as farming began to create a high stock density through government and privately-owned fish and shrimp hatcheries. Since the year 2000, the growth rate of marine fisheries captured in Malaysia has shown a significant impact from 2000 – 2005; between 2006 and 2015, the industry showed an increasing rate of 10% and 13.5%. The growth rate has placed Malaysia 15th in the world aquaculture production and 11th in the marine fisheries capture sector (Food and Agriculture Organisation of the United Nation (FAO), 2018). This trend is due to the fish demand in Malaysia that has increased significantly, as shown by 56.5 kg of fish consumed per person per year in Malaysia - a statistic which is higher than the world average fish consumption, below 20kg per capita (Infofish, 2016). The statistic also indicates that Malaysian consumed fish slightly higher than the Japanese (The Star, 2019). The current highest demand in fisheries in Malaysia is mackerel, followed by squid, Asian seabass, grouper and shrimp. In addition, some Malaysians prefer expensive and high-value fishery products such as cod, salmon, mussels, oysters and abalone (Infofish, 2016).

The increase in demand significantly increases the need for supply from the fisheries industry. The supply must not depend solely on the capture resources.

Aquaculture needs to step in and play a more significant role as a producer. According to Deputy Agriculture and Agro-based Industry Minister Sim Tze Tzin, as quoted in the New Straits Times (2019), "captured fisheries' resources were decreasing at an alarming rate". He added that there had been several initiatives by the government to reduce overfishing and apply aquaculture as the way moving forward. The aquaculture industry helps 8.9% of the national agricultural gross domestic product (Harun, Rambat, & Tukiran, 2018). Ecotourism in the aquaculture industry has begun for more than a decade. Ecotourism is defined as the conservation of the environment by sustaining the well-being and needs of the residents, which includes interpretation and education through responsible travel to the natural areas (TIES, 2015).

Ecotourism in the aquaculture sector has developed into activities such as sportfishing and fish feeding. Ecotourism aquaculture in this research mainly focuses on the offshore area near Pulau Besar in Johor. It is one of the primary destinations for tourists within the Johor Marine Park.

The location selected for ecotourism is dedicated not only to leisure activities among tourists but also to enable visitors to experience and learn about the marine life ecosystem and its current issues. The aquaculture is provided to cater to the food production in the demand and supply chain and breed the fish to be released to the coral area as they improve the ecosystem of the marine life. In addition, the idea of conducting offshore aquaculture is to take advantage of the sea condition for a more sustainable aquaculture process.

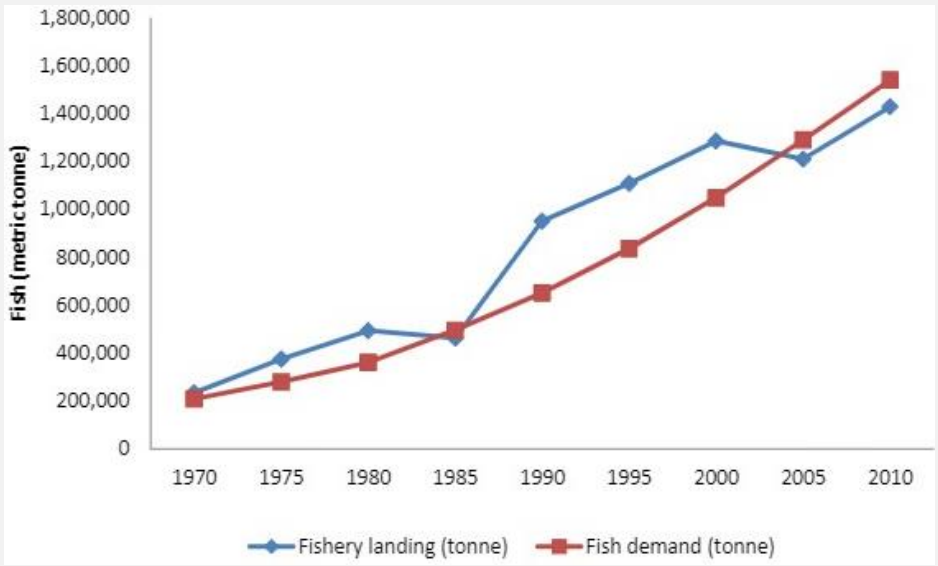

Figure 1: Fish landing and demand in Malaysia, 1970 – 2020 (source: FAO)

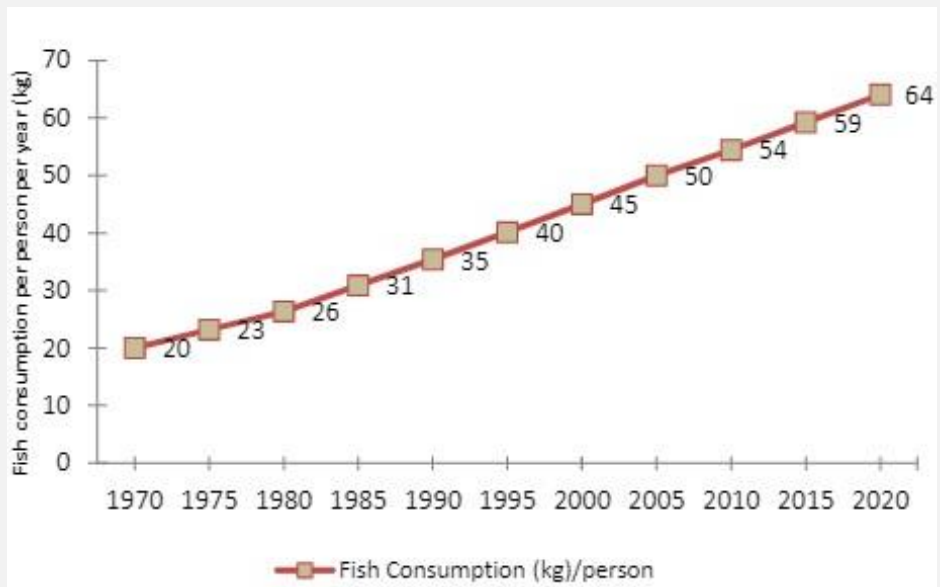

Figure 2: Fish consumption in Malaysia, 1970 – 2020 (source: FAO)

ISSUES AND PROBLEMS

In this study, the environmental aspect serves as the predominant issue affecting the fisheries industry, followed by economic and social aspects. The environment is identified as the main factor and primary concern, as it implicates other factors such as economic and social issues.

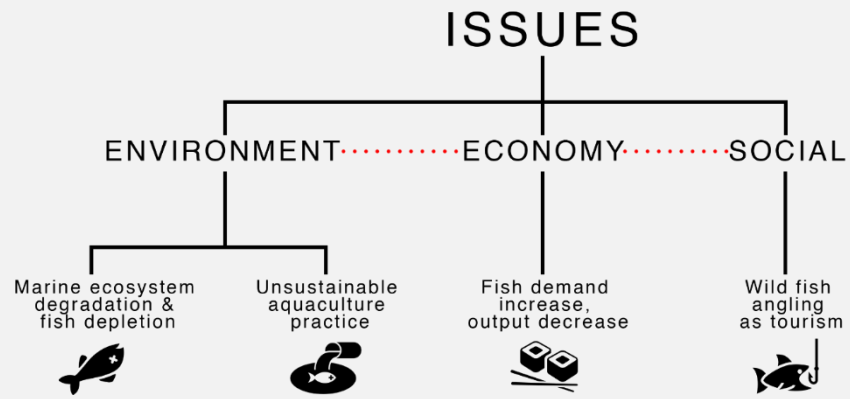

Figure 3: Main issues categories of aquaculture ecotourism in Malaysia

ENVIRONMENT: MARINE ECOSYSTEM DEGRADATION AND FISH DEPLETION

The high demand for fisheries products has put much pressure on the supply process to provide more output. Consequently, trawl nets were introduced to enable large amounts of fish to be caught within a short period. However, the use of this method has significant negative impacts on the sea ecosystems as the unwanted fish species (known as by-catch) are being thrown back to the sea, causing some to survive, but others did not. Besides that, some fishery activities applied bottom trawling to capture more fish on the seafloor near the coral reef. This activity may destroy the coral reef ecosystems that include rare fish species such as Parrotfish which bring balance to the ecosystems.

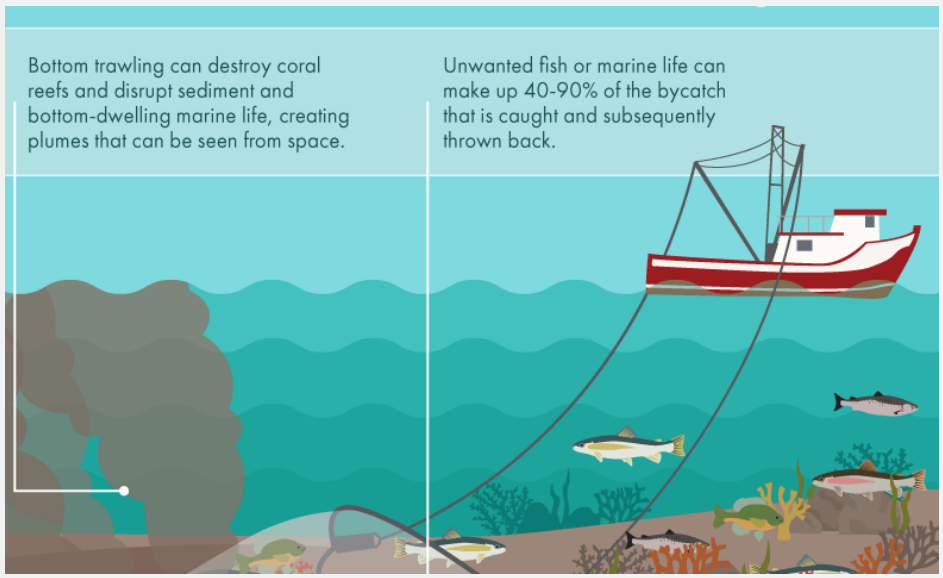

Figure 4: Impacts of bottom trawling (Source: Drop Science)

ENVIRONMENT: UNSUSTAINABLE AQUACULTURE PRACTICE

The aquaculture industry in Malaysia has a variety of culturing system. Among the culturing systems are cockle culture on coastal mudflats; freshwater fish culture in ponds and floating net-cages; marine finfish culture in floating net-cages; mussel and oyster culture using a floating raft and long lines; and seaweed through hanging method (Food and Agriculture Organization of the United Nation (FAO), 2013). According to Tim & Ibrahim (2009), the expected annual growth from 2010 – 2020 is 8.6%, with 790 000 metric tons produced from aquaculture. Despite having production expectations and targets to achieve, the practice of aquaculture needs to consider the sustainability of its surrounding environment. Pollution has become one of the main issues in the aquaculture practice. The primary source of pollutants comes from the additional fish meal that contains fish oil and drugs such as antibiotics. Other sources of pollutions are in the fish sewage that contains uneaten food, waste products, disease, and pathogens that fall onto the ocean floor. Besides pollution, the risk of escaped fish from the aquaculture cage causing interbreed with the wild species may exacerbate disease spread. In addition, marine aquaculture is also subject to threats from predator animals such as hawks and sharks.

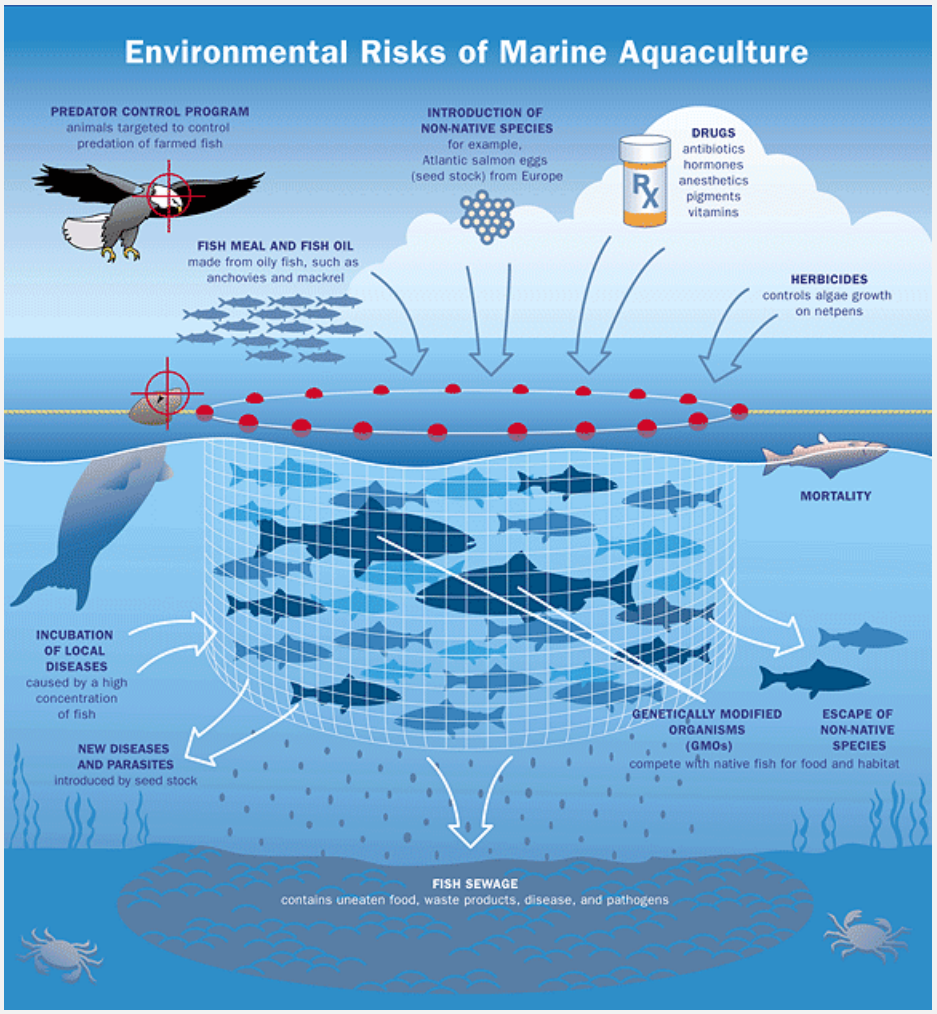

Figure 5: Environmental risk of marine aquaculture
Source: Hutchings et al., 2012

SOCIAL: WILD FISH ANGLING AS TOURISM SPORT

Social issue in the aquaculture industry has several categories, but the most concerning issue is tourism. For decades, tourism has been part of the aquaculture industry when Kelong or fish farms begin to attract visitors as part of the attraction. Kelong initially only for fish farming for food production but in the latter year, it started to open for tourism where the visitor can feed the fish and angling. Some of the angling activity was within the control cage. However, some Kelong has created a wild fish angling at the offshore area. Fishing wild fish is illegal under Malaysian Law. The prohibition is due to the activity itself that disturbs the marine ecosystem. Most fishing is for food, but some are for sport. Fish released from a sport may survive or left damaged from the fishhook.

Figure 6: Wild fish angling at a Kelong in Johor

RESEARCH AIM

The research aims to design a sustainable offshore ecotourism aquaculture centre for fish breeding and production and tourism to spread awareness of the marine life ecosystem and the fish breeding process.

OBJECTIVES

The objectives to achieve the aim are as follows:

1. To identify the type of marine fishes that can increase other marine fish population;
2. To determine sustainable aquaculture practices; and
3. To determine appropriate research facilities for breeding and production.

THEORETICAL FRAMEWORK

The theoretical framework of the research focuses on an offshore site near the coral reef ecosystem to provide sustainable aquaculture and ecotourism that would allow tourists to experience the whole process and inculcate awareness.

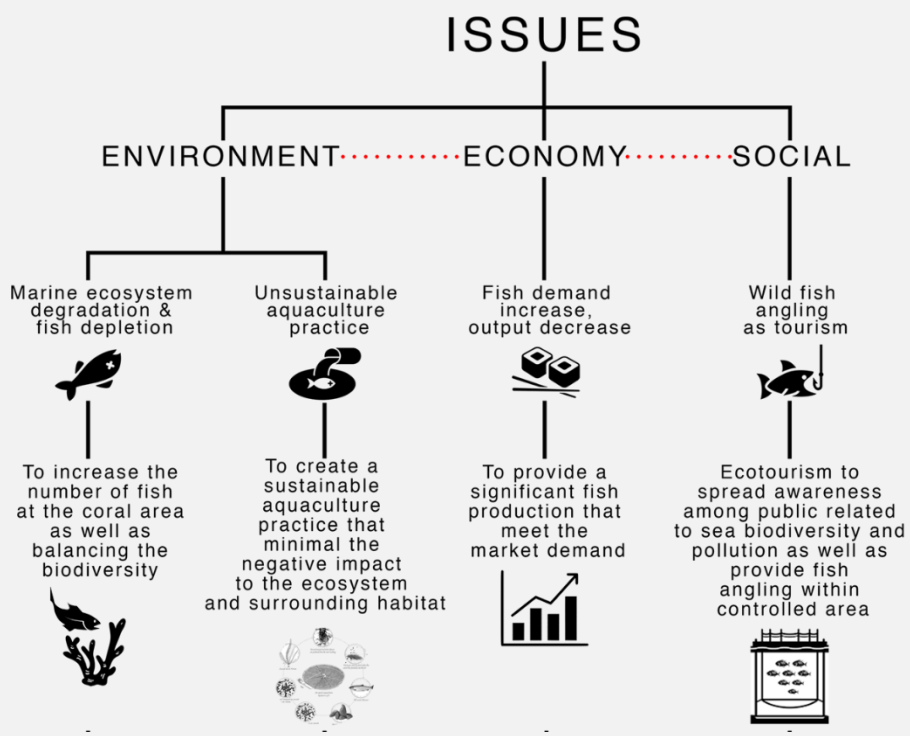

Figure 7: The objectives of the Centre

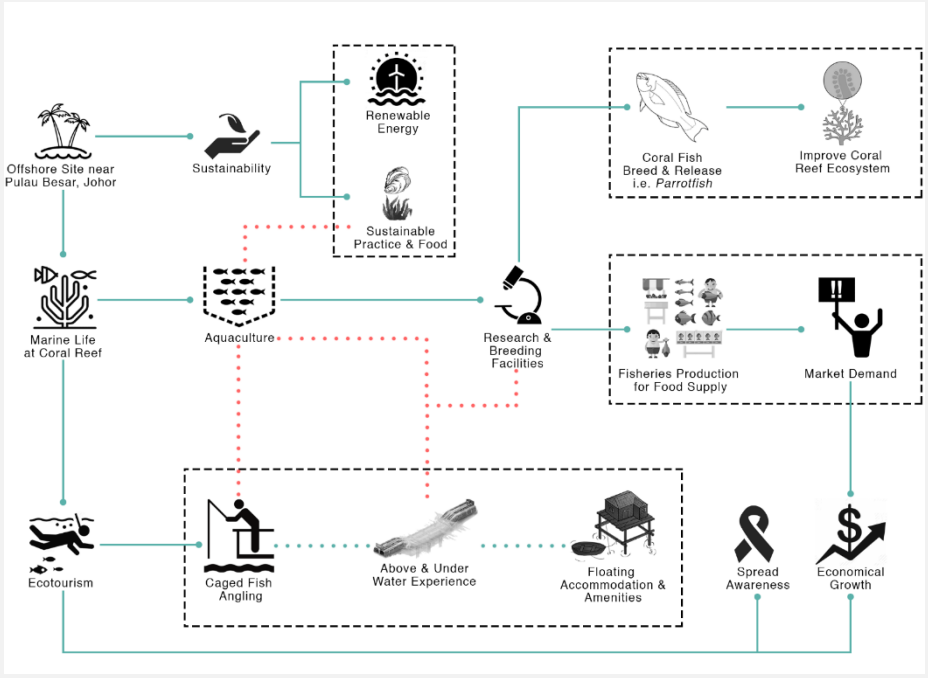

Figure 8: The Centre spaces and programme

METHODOLOGIES

A qualitative research method was adopted for this design research. Data collection method include case study, interview and observation. The process includes analysis and synthesis as part of the overall design process to find solutions that can fulfil the aim and set objectives .

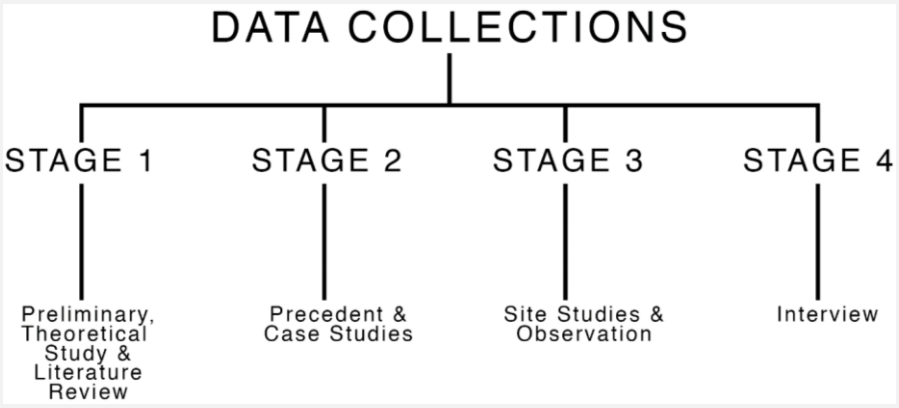

Figure 9: Stages of Data Collection

FRAMEWORK

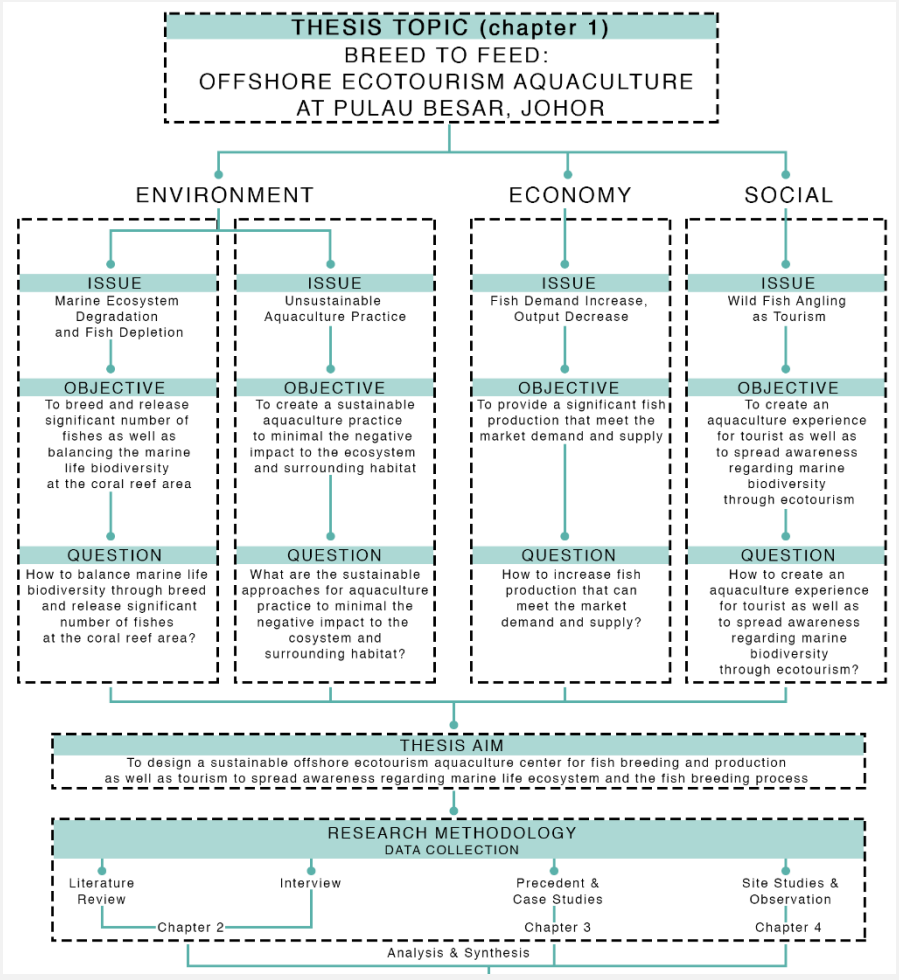

Figure 10: Research structure

SITE INTRODUCTION

The proposed site in the state of Johor, Malaysia, is situated at the southwest of Pulau Besar in the Johor marine park territory, 15.5 km or 26 minutes of boat ride from Mersing. The location is chosen based on several criteria such as:

1. Non-coral zone (more than 10m depth).
2.Marine fish depletion at East Johor
3.Steady current but protected by the island during monsoon season
4.Tourist destination
5. Fisheries activity at the nearest town (Mersing)

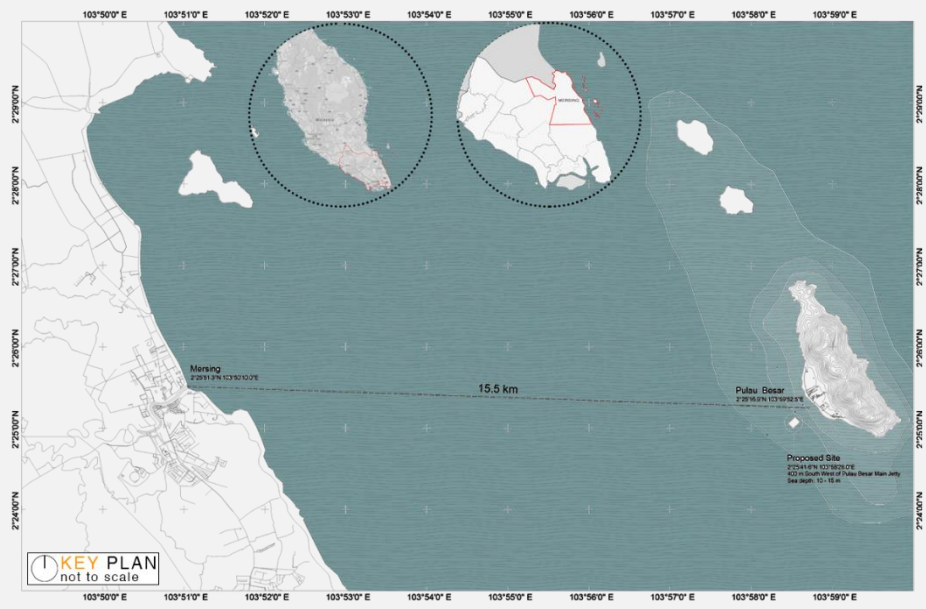

Figure 11: Key plan indicates the location of the proposed site within the boat route from Mersing – Pulau Besar, Johor

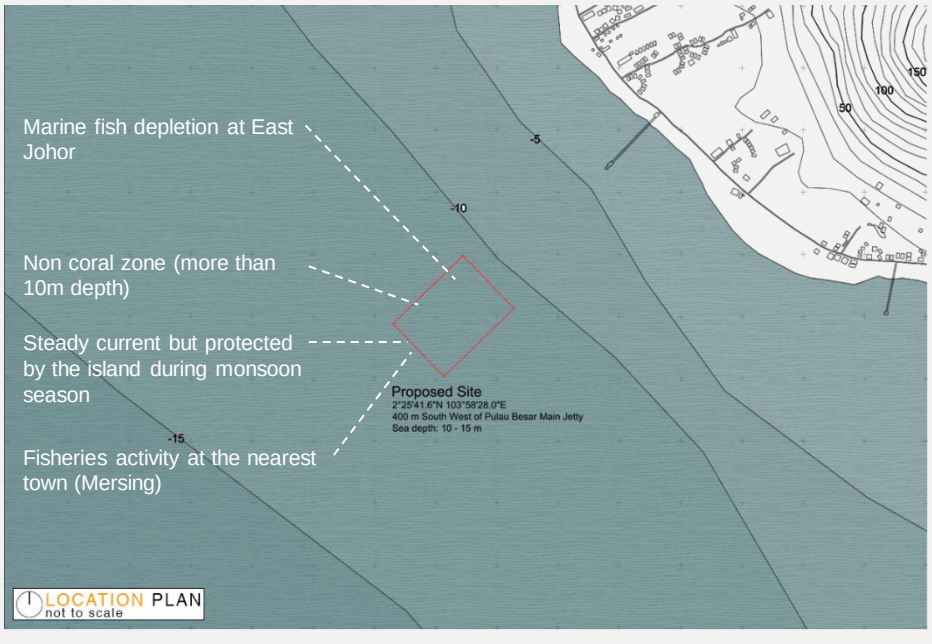

Figure 12: Justification of the proposed site

SITE SYNTHESIS

The overall synthesis is based on the analysis of the provision of a system that can adapt to sea morphology, such as floating, semi-floating and permanent structure systems. The proposed scheme is orientated towards the southwest as it is the primary boat route from Mersing and the strongest wind and current speed direction. Since the average wind speed is the minimum speed of 4m/s, a wind turbine facing southwest was designed and placed at the location. The first floor above the water surface is raised more than a meter to adapt to the differential rise of the water tide and tidal wave.

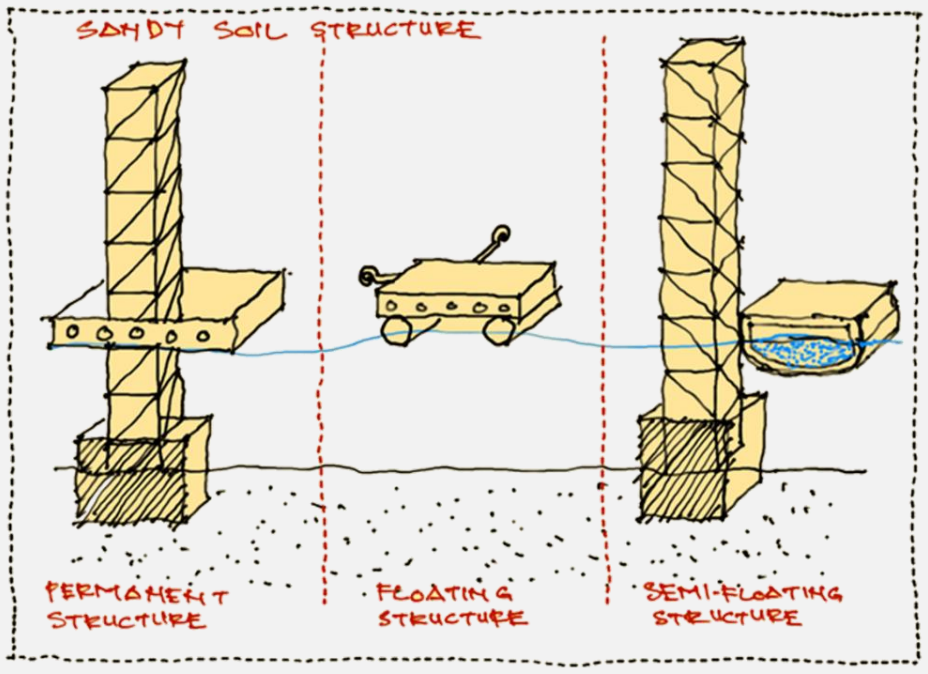

Figure 13: Proposed structural systems

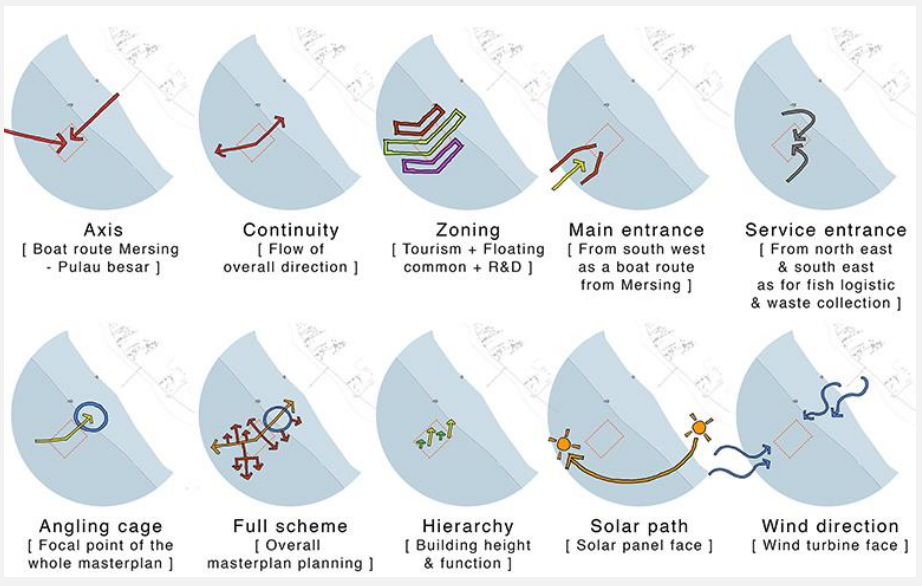

Figure 14: Site synthesis

DESIGN CONCEPT

The current idea of getting away from the hectic city and taking a vacation on an island site is to embrace the tranquility of nature - surrounded by the sea with sea breezes and the melancholic sound of waves. The concept of combining the contrasting culture of working and tourism is to allow the workers and tourists to experience a shared living environment that celebrates the presence of each other without any barriers and thus benefitting from each other's existence. The workers will meet different visitors, and the visitors will meet with the workers through passive and active interactions. The worker-visitor interaction will continuously instill awareness and inform fisheries ecosystems issues, especially fish depletion and other sea-related issues. The visitors will also have hands-on guided coaching from the workers on how to breed fish.

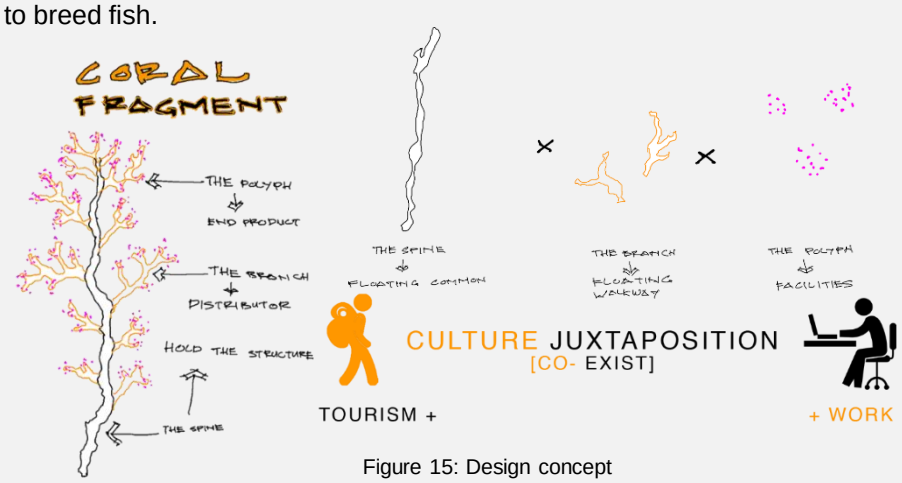

Figure 15: Design concept

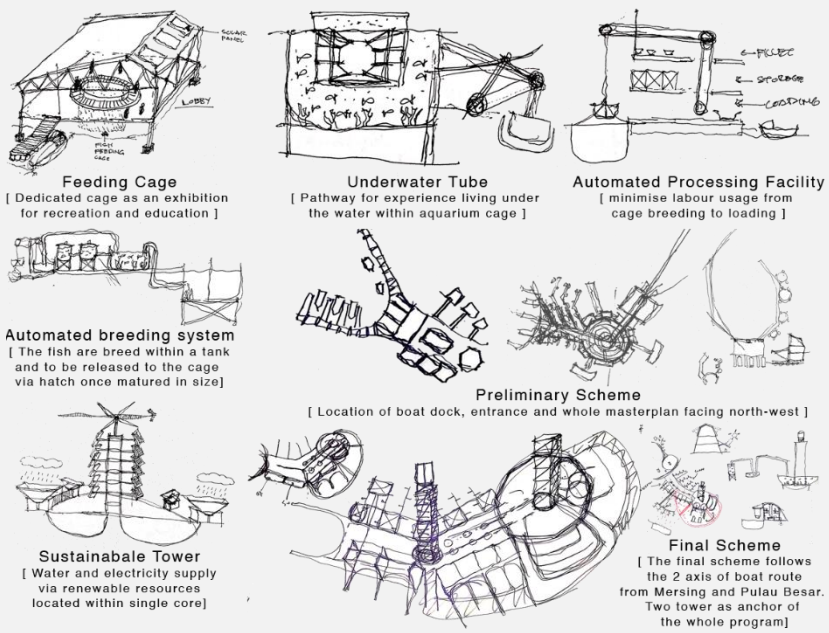

Figure 16: Design ideas

SITE ZONING

The proposed floating site in the sea consists of three zones; tourism, research and development (R&D), and floating common. The tourism zone faces the north side of the complex to reflect the denser resort development at Pulau Besar. The R&D zone on the south side is to allow logistics for fish and research process and services. The common zone or shared areas serves as the public zone to integrate social interaction between tourists and workers. The common zone also serves as the main entrance and angling cage for anglers. The common zone also includes facilities for fish breeding and harvesting processes.

SITE PLANNING

The physical master plan of the entire scheme consists of the detailed building programme of the three zones. Floating common or shared area zone consists of the most facilities such as jetty, gallery, restaurants, sustainable tower, leisure area, and angling cage. The R&D zone consists of a laboratory and fish processing facility, whereas the tourism zone consists of two and four-person cabins. Most of the floating structures or buildings are designed-interconnected to each other via floating walkways. The sustainable tower serves as the converter of wind energy to electricity; and the seawater and rainwater into clean water for daily use. The office or management spaces are located on the upper level of each building structure.

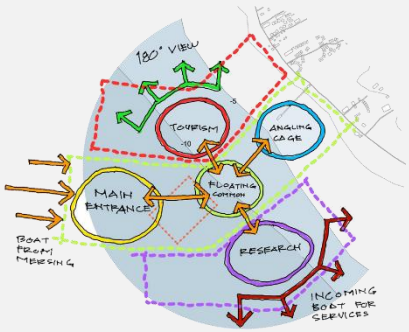

Figure 17: Site zoning

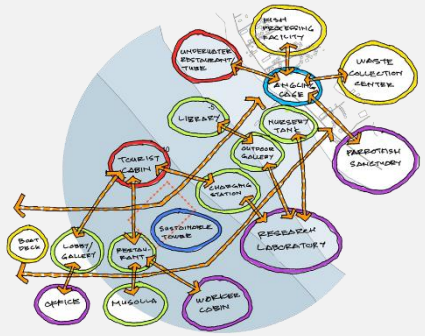

Figure 18: Site planning

DESIGN MORPHOLOGY

The main form of the scheme follows the interconnecting boat route from Mersing to Pulau Besar by having a continuous flow of the proposed shape of the complex in the master plan layout, i.e. from the 'entrance' to the fish processing facility. Most of the building structures designed into two to three floors, with a few having double volume height per floor. The primary entrance approach is from the southwest side as it is the boat route for visitors' arrival. The jetty of the main entrance includes integration with a wave-breaker for a safe boat dock. The service entrance is located on the west and south side of the complex for a logistic reason. The central axis split into three zones. The large angling cage placed at the datum of the complex interconnects all three zones. The angling cage is also where the main activities such as angling, breeding, and harvesting occur. Each building typology is arranged according to the hierarchy and importance of the complex's function as fish research, breeding and angling for the visitors' experience.

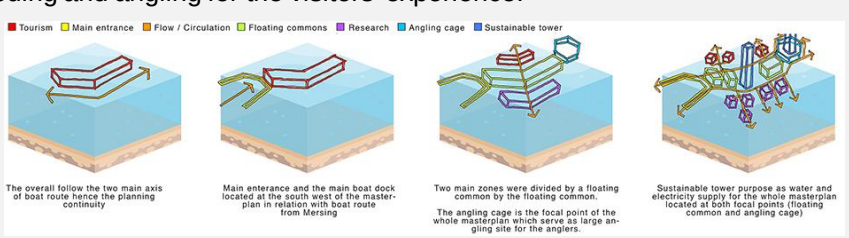

Figure 19: Space planning diagrams

RESEARCH / PROJECT FINDINGS

SITE PLAN

The main idea of the overall site plan layout is to encapsulate the 360° viewing of the sea. It also allows for all-around entrance for any boat to embark on and disembark to serve different purposes. The overall experience of the aquaculture complex starts from the arrival platform at the jetty. The visitors then passes through each building typology until the end-tip of the facility. Each building of the complex is connected via floating covered walkways to complement the experience.

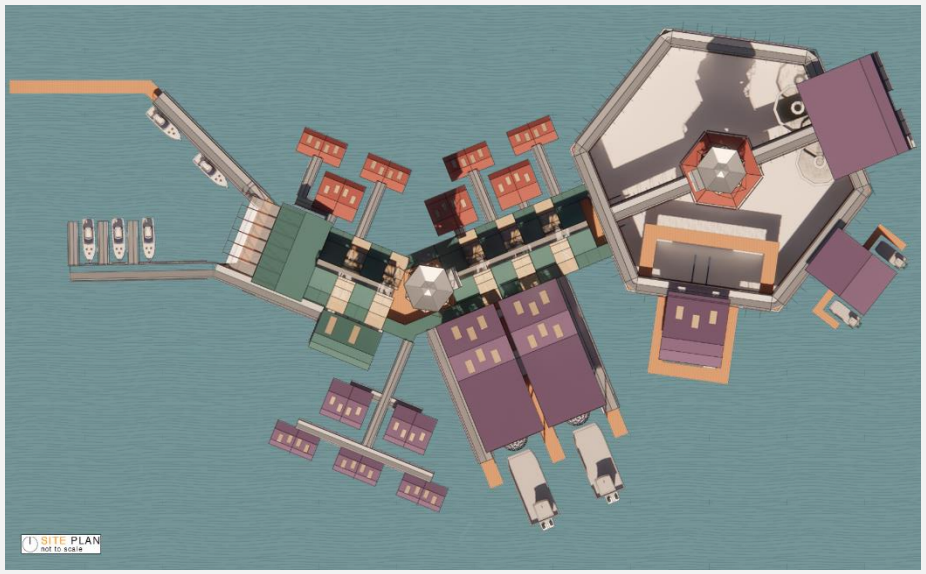

Figure 20: Layout plan

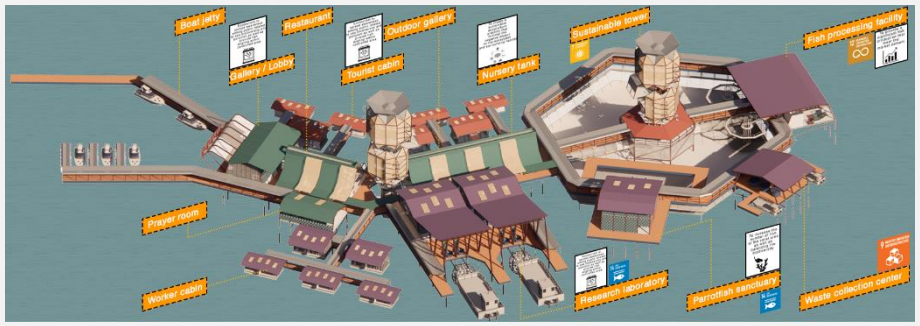

Figure 21: Axonometric of the overall aquaculture complex

Figure 22: User circulation

LEVEL 1

Level 1 is the public zone where most activities at the centre occur. The facilities at this level are connected via covered floating walkways, including the gallery, research laboratory, restaurant, kiosk, leisure area, nursery tank, angling platform, parrotfish sanctuary, and fish processing facility. Floating common or shared area is the neutral zone for tourists and workers to enable social interactions while being in the complex. The angling platform or centre serves as an angling area, kitchen for underwater restaurant, self-grill barbeque area, and anaerobic digester.

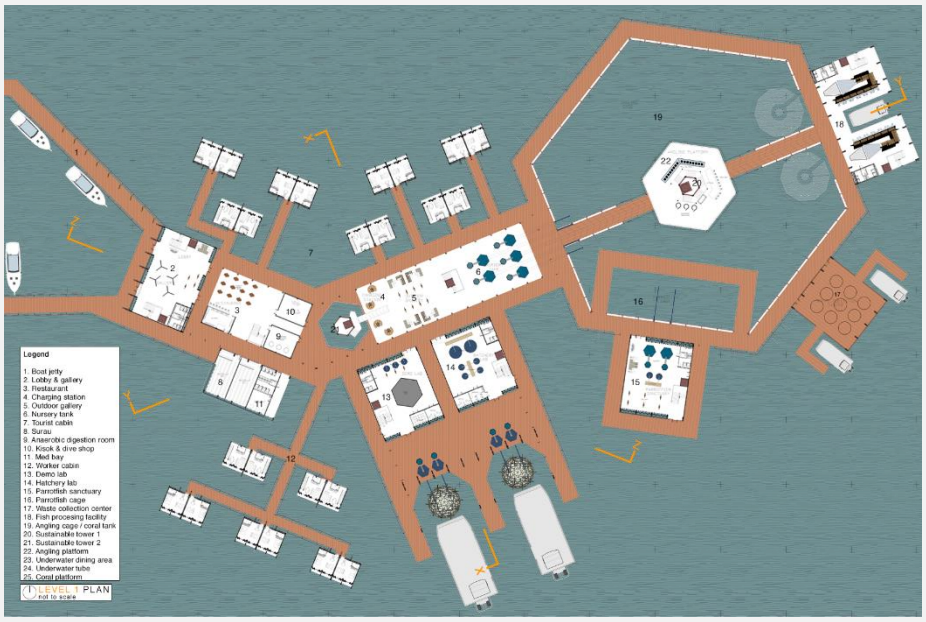

Figure 23: Level 1

UNDERWATER LEVEL

The centre consists of above water and underwater experience. The underwater level allows the visitor to dine in with 360° views and walking around the cage in an underwater glass tube to witness the coral growth and fish breeding. As for scuba divers, they can dive in and feed the fish at the underwater aqua pod.

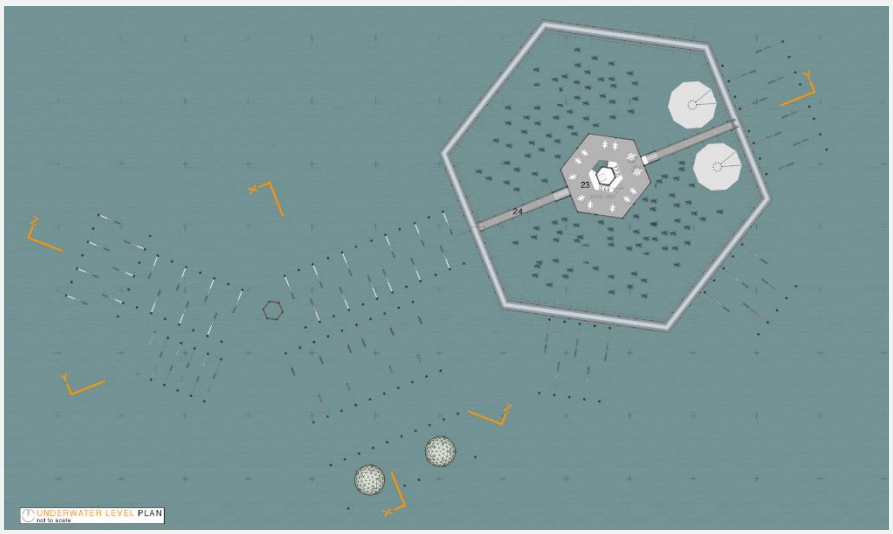

Figure 24: Underwater level

LEVEL 2

Buildings with two levels are designed for tourists and workers' cabin; restaurant and laboratory. The bedroom is placed on level two of the cabin for a four-person cabin. At the restaurant, the upper floor is the dining area for the workers. The height at level 2 is 3.3 meters. The laboratory consists of three floors; on level two, the viewing deck is located for visitors to witness the lifting of the aquapod into the boat and view the outdoor area of the laboratory.

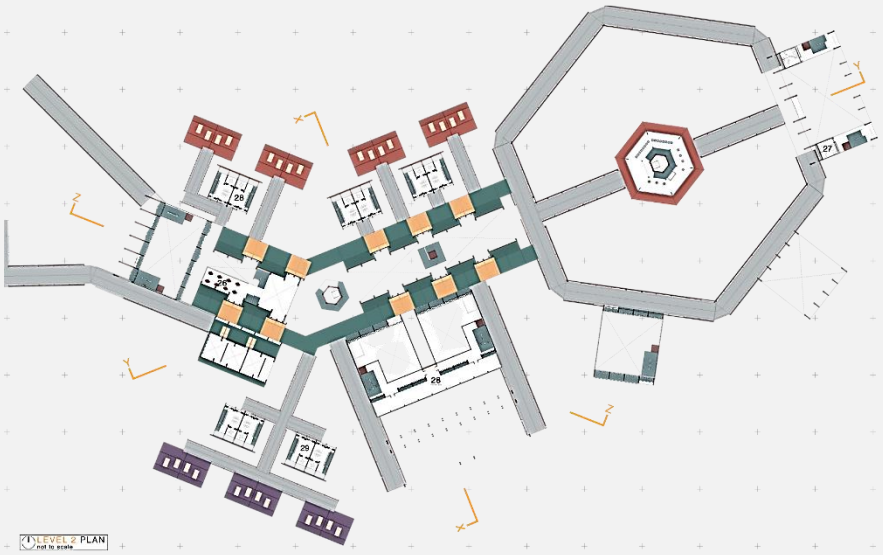

Figure 25: Level 2

Figure 26: Series of banner along the walkway will briefly informed the arriving visitors about the centre

Figure 27: Parrotfish sanctuary is for parrotfish breeding and release to the sea

LEVEL 3

Level three of the centre consists of private zones such as offices, a research laboratory, a multi-purpose hall, and a utility room. Level three is where the height of the lower floor is 6.6 meters. The utility room consists of rainwater collection and reverse-osmosis spaces for turning seawater into clean water for daily usage.

Figure 28: Level 3

Figure 29: The gallery and lobby area are the transition spaces between arrival area and the centre

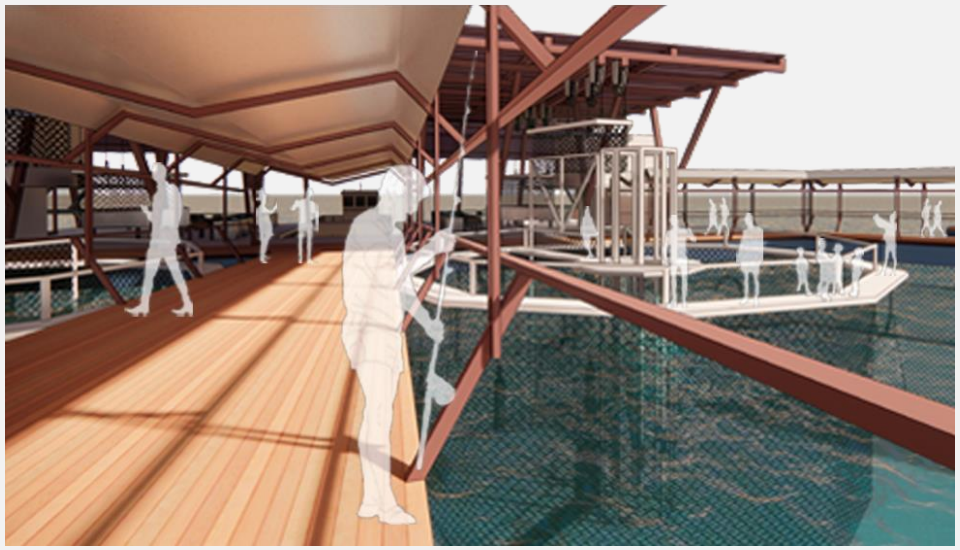

Figure 30: Close connected cage that ease the breeding and harvesting process

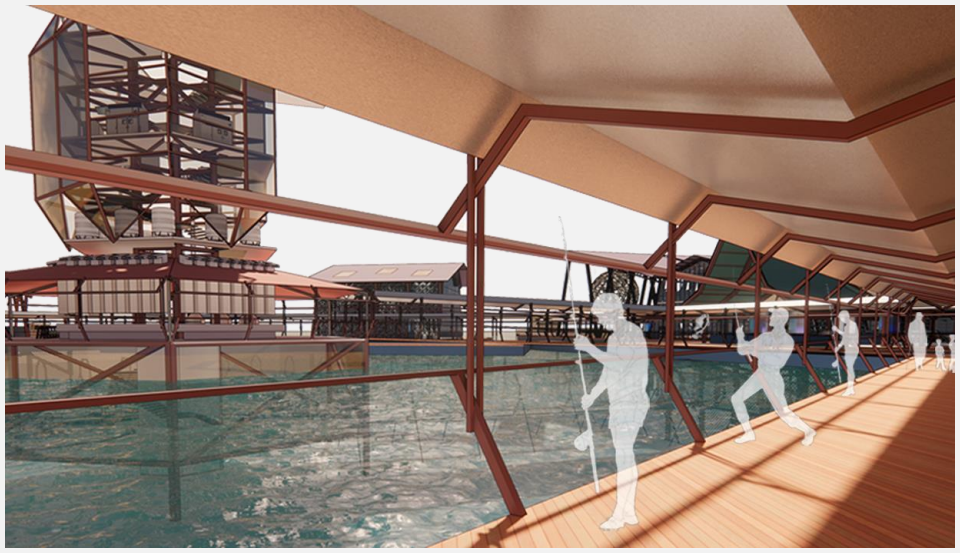

Figure 31: Walkway circulates the angling cage that allows the visitors to pick any angling spot

Figure 32: The aqua-pod allows the visitors to experience swiming with the fish within the cage

Figure 33: Angling platform serves as multi-purpose area for angling, self-service grilling or cooked by a dedicated cook

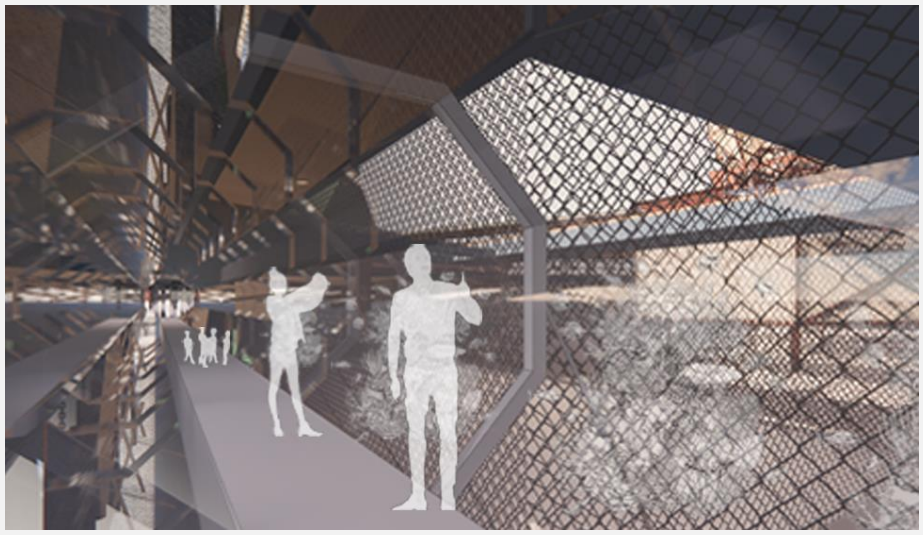

Figure 34: 360° angle view of walkway circulates the angling cage

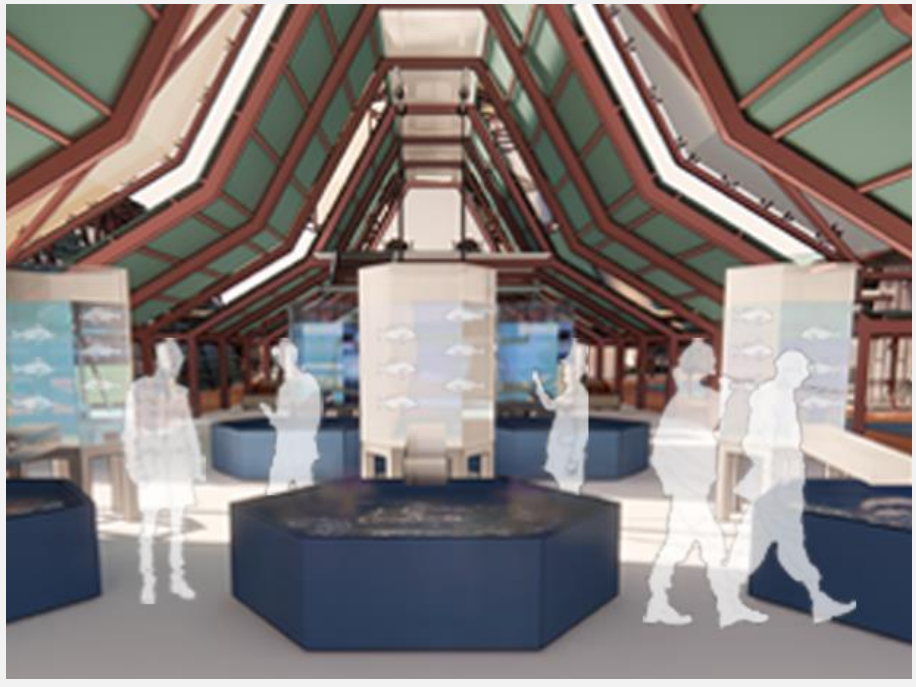

Figure 35: Automated fish breeding tank release the matured fish into the angling cage

Figure 36: Hands on learning from the researcher with real life size coral tank

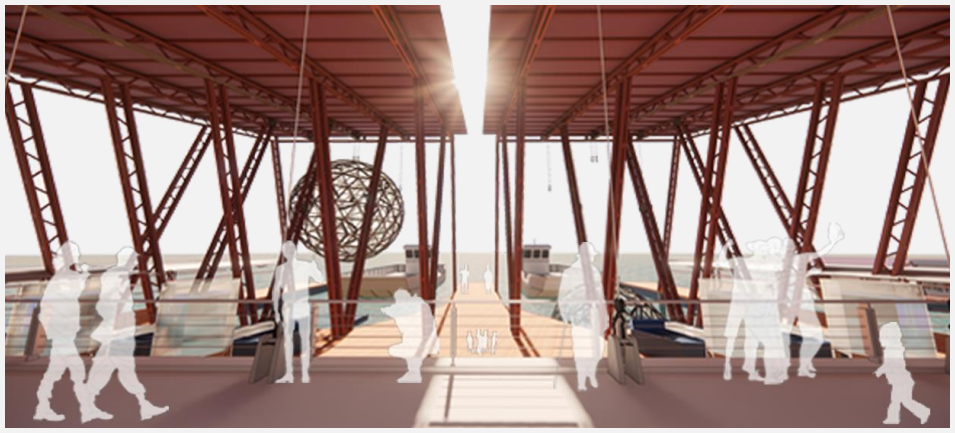

Figure 37: Aquapod being raise contained with fishes into the fishing boat

Figure 38: Harvested fish from the cage into the automated conveyor belt for sorting and packaging process

CONCLUSION

This research had produced a holistic and sustainable design of an offshore aquaculture centre that can increase the marine fish population and food source. At the same time, the centre provides tourism and educational knowledge to appreciate marine biodiversity for the sustainability of the fishes for future generation, thus addressing the issues of fish depletion.

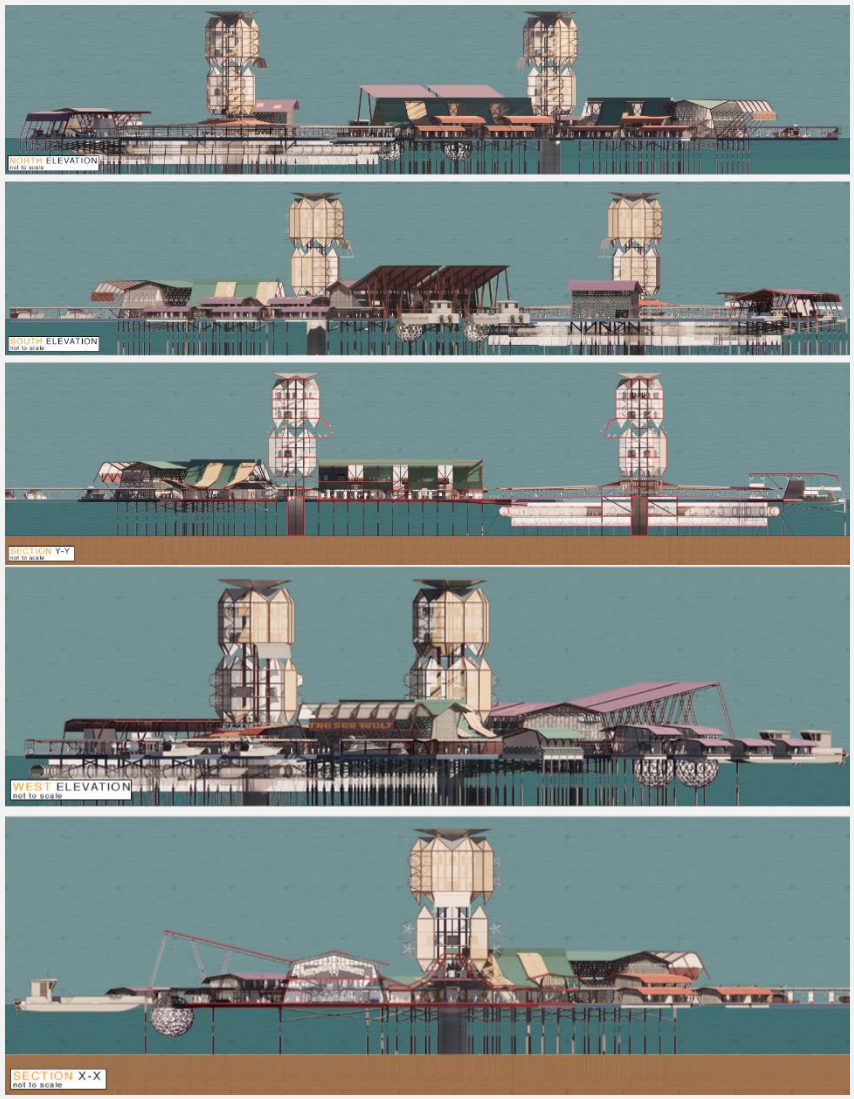

Figure 39: Elevations and Sections

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