2. PROJECT DESCRIPTION

2.1 Purposes and Objectives of the Project

The Project involves the establishment of a new FCZ at Outer Tap Mun for mariculturists to operate their fish rafts. The main purpose and objective of the Project is to provide opportunities to develop a newer type of deep-water mariculture, create room for the mariculture sector to grow further and attracting new entrants, potentially allowing capture fishermen to switch to a sustainable mode of operation.

2.2 Background and History of the Project Site

The Project site is located to the waters west of Tap Mun in the Northeast New Territories (***Figure 1.1***). The Project area will be approximately 55 hectares (~1,630 m long and ~330 m wide) in size and lies in between two land masses, Tai Leng Tun and Grass Island (Tap Mun). Hoi Ha Wan, which was established as an SSSI in 1989 (2) due to the high coral coverage and designated as a Marine Park in 1996 (3), is located over 700 m west of the Project site. Sai Kung West Country Park is also located over 700 m to the west of the Project site. The Project site is classified as being semi-exposed with protection from prevailing winds during the majority of the year, with the area only being susceptible to northerly winds. The Project site is situated in an area with a water depth ranging from -10 to -15 m.

The land surrounding the Project site is generally rural area with no existing or planned developments within the vicinity of the FCZ area. There is no historic use of the Project site based on the existing information. The Project is not located within and in the vicinity of historical, or existing infrastructure facilities. No historical contamination concern is identified within the Project site. The closest residential area / village is located in Tap Mun and is over 400 m away from the Project site and an existing fish culture operation at Tap Mun FCZ is located ~300 m from the Project site.

In terms of ecological conditions, Outer Tap Mun FCZ has been identified as being within a nursery area of commercial fisheries resources with majority of fisheries resources of low commercial value. Coral communities have been recorded in the vicinity of the Project site.

2.3 Environmental Benefits of the Project

2.3.1 Sustainable Mariculture Development in Hong Kong

AFCD has been actively supporting the modernization and sustainable development of the local fisheries industry and enhancing their competitiveness through a multi-pronged approach. Amongst the various measures that have been recommended, the designation of new FCZs and the promotion of the adoption of advanced and environmentally friendly culture practices are practical means to promote mariculture development. The sustainable development of mariculture and the designation of new FCZs can have the following benefits:

- Increase local mariculture production to support local demand for live marine fish, with a quality, healthy, safe, diversified and stable supply with low carbon footprint;
- Provide an avenue for capture fishermen, who face various operational challenges, to switch to a sustainable operation mode, which in turn alleviates local fishing pressure and promotes the conservation and recovery of fisheries resources and preservation of the marine environment;
- Allow mariculturists of the existing FCZs to consider pursuing modernised and sustainable modes of operation in the new FCZs, such that the marine environment of the existing FCZs can improve when the level of mariculture activities there decreases;

(2) Planning Department (2005) Hoi Ha Wan.

(3) AFCD (2020) Designate Marine Parks and Marine Reserves.

- Larger production scale enabled with technology can allow operating costs to be optimised, and hence improving cost-efficiency and competitiveness;
- Provide high value-added fisheries products and assists the fisheries sector to seize the opportunities in the Greater Bay Area (GBA) and other places;
- Attract new entrants and business opportunities to further grow the sector and related trades organically, also providing employment opportunities.

Overall, the sustainable development of mariculture in Hong Kong, by means of designating new FCZs, plays a critical role in fostering support for the fisheries industry which is an important local cultural asset with a long history and valuable contributions to Hong Kong's economy and society. A sustainable fisheries industry will help establish and maintain marine biodiversity such that our future generations can enjoy a diverse and rich marine ecological environment.

Deep sea mariculture with advanced technologies is a global trend in sustainable fisheries development. The environmental considerations of different development options including site selection to establish the new FCZ for sustainable mariculture at deeper and open water are further discussed in ***Section 2.5***.

2.3.2 Advanced Mariculture Operation in Deeper Waters

Advanced mariculture technologies which promote modernisation of mariculture activities and sustainable modes of operation will be used at the new FCZ. The new FCZ at deeper water depths allows fish cages of larger size to be used; and while more fish stock can be kept within a larger area of the water column to achieve optimal stock density and a good mariculture environment with sufficient circulation, sufficient separation distance between the bottom of the fish cage and the seabed as well as among fish cages can still be maintained to minimise water quality impact. This setting together with the open sea environment allows adequate water circulation and prevents the build-up of organic content and degradation of the nearby marine environment. Consequently, organic content is also not built up on the seabed and maintenance dredging and sediment removal are therefore not required for FCZ in deep waters, and the associated water quality impacts and related ecological and fisheries impacts can be avoided.

The framework of fish cages would use weather-resistant materials such as high-density polyethylene (HDPE) and steel truss cages which are highly durable compared to traditional cages on rafts and are less prone to damage that may cause general / floating refuse on the sea. These modern fish cages can also be a submersible/ semi-submersible design to withstand strong waves and surges such that the fish cages can remain onsite during typhoons with minimal fish loss/ escape. This would reduce the need of fish cage relocation during adverse weather and thereby reducing the risk and potential impact on local ecology and fisheries associated with fish escape.

Only pellet feed or alternative feed with better feed conversion ratio will be permitted within the proposed FCZ. Pellet feed generally floats on the water surface that could minimise feed wastage to seabed, thus reducing the potential pollution loading and minimising impacts to water and sediment quality. On the other hand, pellet feed contains less moisture (~10%) that can be easily stored at FCZ and minimise the potential transmission of parasitic and infectious disease to fishes, thus reducing potential organic waste generation due to feed wastage and fish carcasses and dead fish arising from the fish culture operation.

In addition, operations at these larger fish cages at deeper waters will involve green technology and automation, such as the use of renewable energy (solar and wind energy systems) and automated/ remote fish feeder machines to reduce feed wastage and physical labour. The use of technology and automation can reduce emissions (e.g. from diesel generators for electricity generation), wastes and water quality impacts.

Fish farm structures will provide artificial substrates as potential marine habitats. The structures will form habitat and shelter for fishes and a range of marine organisms. With the use of Integrated Multi-trophic Aquaculture (IMTA) (***Section 2.6.2.3***), a more complex habitat with food webs can be built where wastage from mariculture is the food sources for filter feeders, deposit feeders and other fishes around the fish farm. This may have potential positive effect on marine ecological resources within and adjacent to the Project site. Some of these species serve not only as nutrient sinks which help maintain the water quality of the surrounding area, but also as harvested species to improve commercial return.

All in all, the advanced modes of mariculture operations in deeper waters are considered to be by far more environmentally friendly than the more conventional modes of operations in the existing FCZs. Locally produced fisheries products at this scale can provide low carbon, sustainable and secure food sources for Hong Kong.

2.4 Scenarios with and without the Project

2.4.1 Without Project Scenario

In the absence of new FCZs, the fishery sector would need to rely on existing FCZs to provide grounds for mariculture development. Consequently, the industry would have limited capacity to make use of advanced, and most importantly more environmentally friendly, mariculture technologies which work best in deeper waters and have limited potential and cost-efficiency to be adopted in the existing FCZs mostly in shallow waters. Even though some elements of the mariculture operations could be modernised and improved, e.g. use of more weather resistant and durable materials, renewables energy and technology, better quality of fish feed etc., there is little room to enhance the mariculture environment and production in the existing FCZs given the lack of incentives from the existing family-based, small-scale operations, and the reluctance of new entrants to invest in mariculture in these existing FCZs which is once perceived as environmentally constrained and financially risky. These existing FCZs operating as status quo are not suitable for the sustainable development of mariculture in Hong Kong. Without new mariculture sites and methods, it will be challenging for mariculturists to invest and diversify, mariculture production will continue to decline in quality and quantity with reference to the production trend of previous years, fishermen's livelihood will be adversely affected, and the development of the fishery sector will be halted.

2.4.2 With Project Scenario

The proposed FCZ at Outer Tap Mun is one of the measures that support the sustainable development of mariculture in Hong Kong through the designation of new FCZs. With the Project in place, the environmental benefits associated with the sustainable development of mariculture and the use of advanced mariculture operation (***Section 2.3***) can be realised. Ultimately, in line with the long-term goals developed by the Committee on Sustainable Fisheries that AFCD set up in late December 2006, the establishment of new FCZs can contribute to the sustainable management of marine resources and preservation of the marine environment for our society to enjoy, while providing a supply of fresh and quality fisheries products to local consumers, and creating job opportunities to the fishery sector and related trades such that fishermen and fish farmers can achieve self-reliance and maintain their livelihoods in the changing business operating environment.

2.5 Consideration of Different Development Options

As the main purpose and objective of the Project is to provide opportunities to develop a newer type of deep-water mariculture, create room for the mariculture sector to grow further and attract new entrants, potentially allowing capture fishermen to switch to a sustainable mode of operation, different development options have been explored.

2.5.1 Option on Project Siting

2.5.1.1 Development Option by Expanding the Existing FCZs

The development option by expanding the existing FCZs was explored. Given most of the existing FCZs are located in inshore areas with shallow water depths, these locations are not feasible to support the more advanced type of deep-water mariculture in line with the global practice. In addition, there exists other development constraints around the existing FCZs, such as existing marine usage, ecological sensitive receivers, etc. Sediment removal may also be required periodically to maintain a suitable environment for mariculture. As such, the environmental impacts are likely to be more detrimental for FCZs in inshore areas with shallow water depths. This will limit the potential for developing sustainable mariculture and promoting the modernisation and competitiveness of the fisheries industry. Therefore, expansion of existing FCZs is not a feasible development option for the Project.

2.5.1.2 Establishment of New FCZ Sites

The criteria for the site selection of sustainable mariculture were reviewed with reference to international guidelines (e.g. the Food and Agriculture Organization (FAO)), which include minimum water depth, wave exposure, water quality, the compatibility with the existing usage and environment, accessibility and infrastructure and site security. The key considerations of these criteria are summarised in ***Table 2.1***.

Table 2.1 Summary of the Key Considerations of Site Selection Criteria

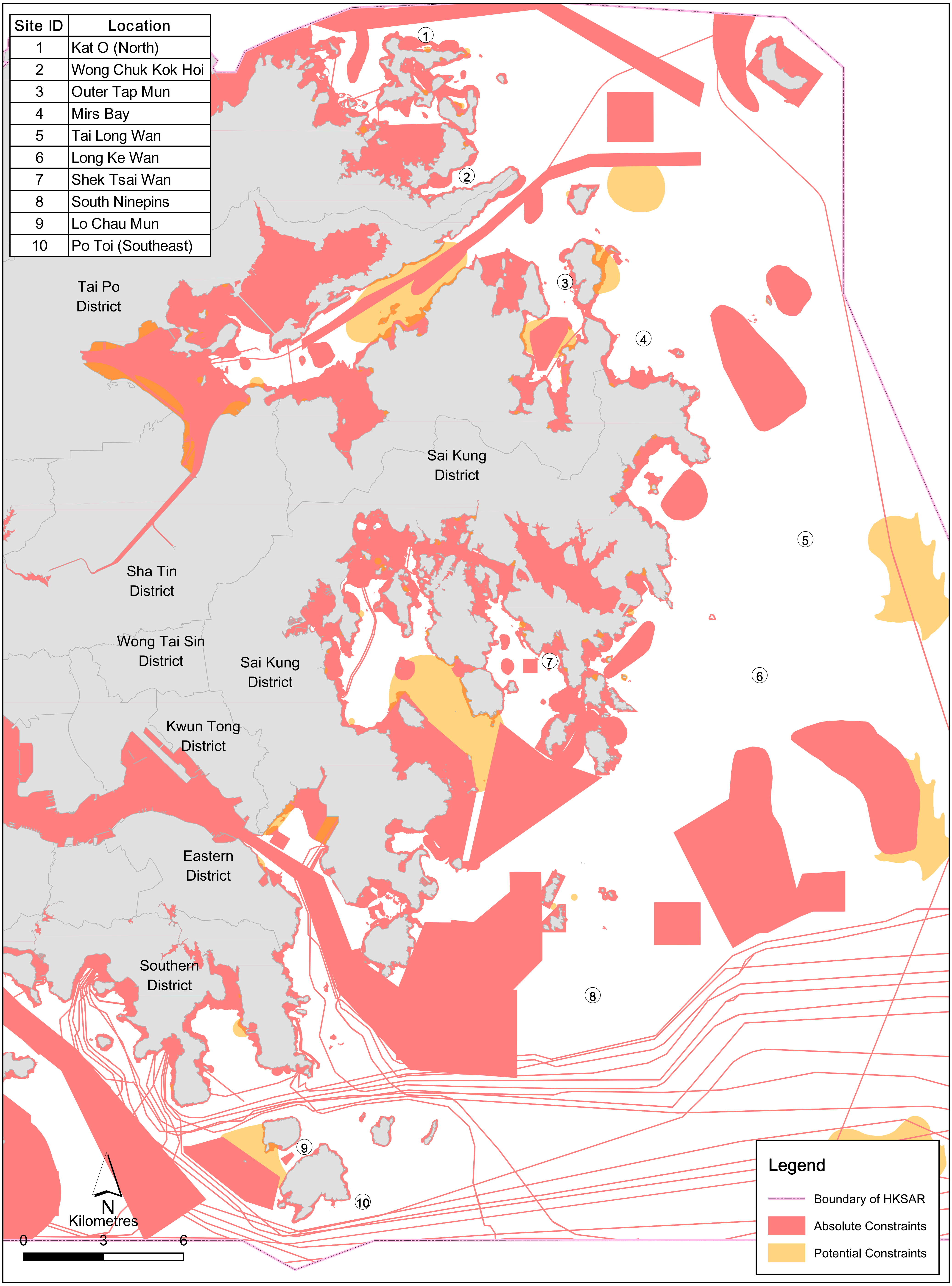
Criteria	Key Considerations
Minimum Water Depth	▪ Allow sufficient clearance (at least 2 m) of the bottom of cage to the seabed. ▪ Water depth of preferably > 10 m for the use of advanced type of deep-water mariculture.
Wave Exposure	▪ Greater wave exposure will have better water flushing and hence facilitate the dispersion of pollution loading from mariculture operation in general. ▪ While there could be higher potential risk of cage damage due to greater wave exposure (e.g. during monsoon wind / typhoon), the modernised cages with advanced technologies (see ***Section 2.6.2***) have been designed to withstand strong wind, strong wave and strong water currents. Therefore, site with greater wave exposure would be preferred.
Water Quality	▪ Oceanic conditions are generally preferred for mariculture (e.g. culturing of grouper / snapper species). ▪ Oxygen consumption for each species of fish varies, with pelagic fish requiring more oxygen than demersal species. Dissolved oxygen is preferably no less than 4 mg/L for pelagic fish or 3 mg/L for demersal fish in general. ▪ Levels of turbidity / suspended solids are low enough to minimize clogging of fish gills which may lead to mortality from asphyxiation or cause gill epithelial tissues to proliferate and thicken. ▪ Higher water flushing rate and lower levels of nutrients, such as chlorophyll-*a*, nitrate, phosphate, are preferred to minimize potential algal bloom and hence reduce the likelihood of red tide occurrence.

Criteria	Key Considerations
Compatibility with the Existing Usage and Environment	▪ Conflicts with existing / planned / potential usage of coastal resources such as shipping, fishing, recreational activities, submarine utilities, development projects and other industries are avoided as far as practicable. ▪ Key environmental sensitive receivers, such as marine parks and marine reserve, coastal protection areas, seawater intake point, Sites of Special Scientific Interest (SSSIs), key coral communities, artificial reefs, marine mammal habitats, wintering and nesting grounds for birds, mangroves and horseshoe crab habitats are avoided as far as practicable. ▪ Sites should be located at remote areas to minimise impacts on air quality, noise and visual sensitive receivers.
Accessibility and Infrastructure	▪ Proximity to jetty and main road is preferred for distribution of fisheries products, transport of feed, fingerlings, fuel, equipment, supplies and other necessities. ▪ Presence of infrastructure is preferred to facilitate daily mariculture operation.
Site Security	▪ Sites preferably in areas not frequented by public to prevent poaching.

A site search was conducted to identify suitable locations in Hong Kong waters for the development of new FCZs considering the above site selection criteria. Incompatible areas with absolute constraints were excluded, while the compatible areas for a suitable location were considered taking into account environmental, physical and operational constraints. The new FCZ sites should avoid encroaching into ecological sensitive receivers (e.g. marine parks, coral habitats of high ecological value and areas of high fisheries importance) to avoid impacts to marine ecology and fisheries. The new FCZ sites should be located at remote area to minimise impacts on air quality, noise, and visual sensitive receivers. In addition, the locations should have better water flushing rate for mariculture to allow adequate water dispersion and prevent the build-up of organic content and degradation of the nearby marine environment. Consequently, organic content is also not built up on the seabed and maintenance dredging and sediment removal are therefore not required for FCZ in deep waters, and the associated water quality impacts and related ecological and fisheries impacts can be avoided.

As western Hong Kong waters are under the influence of freshwater discharges from the Pearl River Estuary, eastern Hong Kong waters are preferred when identifying suitable sites for new FCZs and various areas for development of FCZs were identified (***Figure 2.1***). While these areas have avoided encroaching into ecological sensitive receivers and are located at remote areas to minimise impacts on air quality, noise, and visual sensitive receivers, the viability of these areas was further determined based on the following key criteria for mariculture.

- **Higher flushing rate**: Higher flushing rate would facilitate water circulation to avoid accumulation of pollutants that may affect fish health. In addition, higher flushing rate of a site will generally have a higher carrying capacity per unit area that can support mariculture activities under sustainable environmental conditions. In essence, higher flushing rate can minimize impacts on water quality and marine ecological and fisheries resources of the surrounding environment.
- **Accessibility and infrastructure**: The FCZ area should be near a shore preferably with a jetty for boat connections with FCZ and near main road networks for land transportation of the mariculture products. Good accessibility facilitates distribution of fisheries products, transport of feed, fingerlings, fuel, equipment, supplies and other necessities. The presence of infrastructure, e.g. communal raft, is also important to facilitate sustainable and effective mariculture operation



ERM

Figure 2.1

Potential Areas for Development of Fish Culture Zones based on Constraint Mapping

File: T:\GIS\CONTRACT\0549925\mxd\EIA\0549925_Potential_Areas_for_Development.mxd
Date: 8/9/2022

by providing storage (e.g. for pellet feed) and equipment (e.g. air pumps, water quality monitoring equipment). This would also mean that the construction of new infrastructure can be avoided, hence avoiding the associated impacts on the environment.

- **Site security**: As FCZ area is located in open waters, site security will be one of the considerations. The FCZ should preferably be sited at sites not frequented by public to prevent poaching.

In addition, consultation with relevant stakeholders was conducted to determine the sites suitable for establishment of new FCZs. The summary of site evaluation is presented in ***Table 2.2***.

Table 2.2 Summary of Site Evaluation

Potential Site	Evaluation	Preferred Site (Y/N)
Kat O (North)	▪ The site is semi-exposed and susceptible to the prevailing northeastern winds during the winter months. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is limited and the nearest jetty is located at Sha Tau Kok with restricted entry. ▪ The site is close to Hong Kong SAR boundary. Site security could be a potential concern.	N
Wong Chuk Kok Hoi	▪ The site is semi-exposed and susceptible to the prevailing northeastern winds during the winter months. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is favourable, including Wong Shek Pier and Tai Po piers which are accessible to public and connecting to main road network. ▪ The site is not frequented by public and shielded by Wong Wan Chau. Site security is not a concern.	**Y**
Outer Tap Mun	▪ The site is semi-exposed and sheltered by Tap Mun on the east side. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is favourable, including Wong Shek Pier and Tai Po piers which are accessible to public and connecting to main road network. ▪ The site is located near Tap Mun and not frequented by public. Site security is not a concern.	**Y**
Mirs Bay	▪ The site is exposed to wind from all directions. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is favourable, including Wong Shek Pier and Tai Po piers which are accessible to public and connecting to main road network. ▪ The site is not frequented by public and is shielded by Tap Mun and Nam She Wan. Site security is not a concern.	**Y**
Tai Long Wan	▪ The site is exposed to wind from all directions. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is limited and the nearest jetty is located at Sai Kung.	N

Potential Site	Evaluation	Preferred Site (Y/N)
	▪ The site is close to Hong Kong SAR boundary. Site security could be a potential concern.	
Long Ke Wan	▪ The site is exposed to wind from all directions. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is limited and the nearest jetty is located at Sai Kung. ▪ The site is close to Hong Kong SAR boundary without shielding by land mass. Site security could be a potential concern.	N
Shek Tsai Wan	▪ The site is sheltered. Flushing rate is expected to be less suitable for mariculture. ▪ Accessibility is favourable, including Sai Kung piers which are accessible to public and connecting to main road network. ▪ The site is not frequented by public and shielded by High Island. Site security is not a concern.	N
South Ninepins	▪ The site is exposed to wind from all directions. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is limited and the nearest jetty is located at Sai Kung / Shau Kei Wan. ▪ The site is situated in open water without shielding by land mass. Site security could be a potential concern.	N
Lo Chau Mun	▪ The site is exposed to wind from all directions. Flushing rate is expected to be suitable for mariculture. However, due to the deep water of the area (>60m deep), there exists constraint in deploying suitable cages for mariculture activities. ▪ Accessibility is favourable and the nearest jetty is located at Stanley. ▪ The site is not frequented by public and shielded by Beaufort Island and Po Toi. Site security is not a concern.	N
Po Toi (Southeast)	▪ The site is exposed to wind from all directions. Flushing rate is expected to be suitable for mariculture. ▪ Accessibility is favourable and the nearest jetty is located at Stanley. ▪ The site is not frequented by public and shielded by Po Toi. Site security is not a concern.	**Y**

In summary, four sites, namely Wong Chuk Kok Hoi, Outer Tap Mun, Mirs Bay, Po Toi (Southeast) (***Figure 2.2***), are selected for the establishment of new FCZs based on the site selection criteria and views from stakeholders. These sites avoid the encroachment to areas with ecologically important habitats, such as marine parks / reserve, coral habitats with high ecological value, key marine mammal habitats, wintering and nesting grounds for birds, mangroves and horseshoe crab habitats. The identified sites are also relatively remote, which minimise impacts on air quality, noise and visual sensitive receivers.

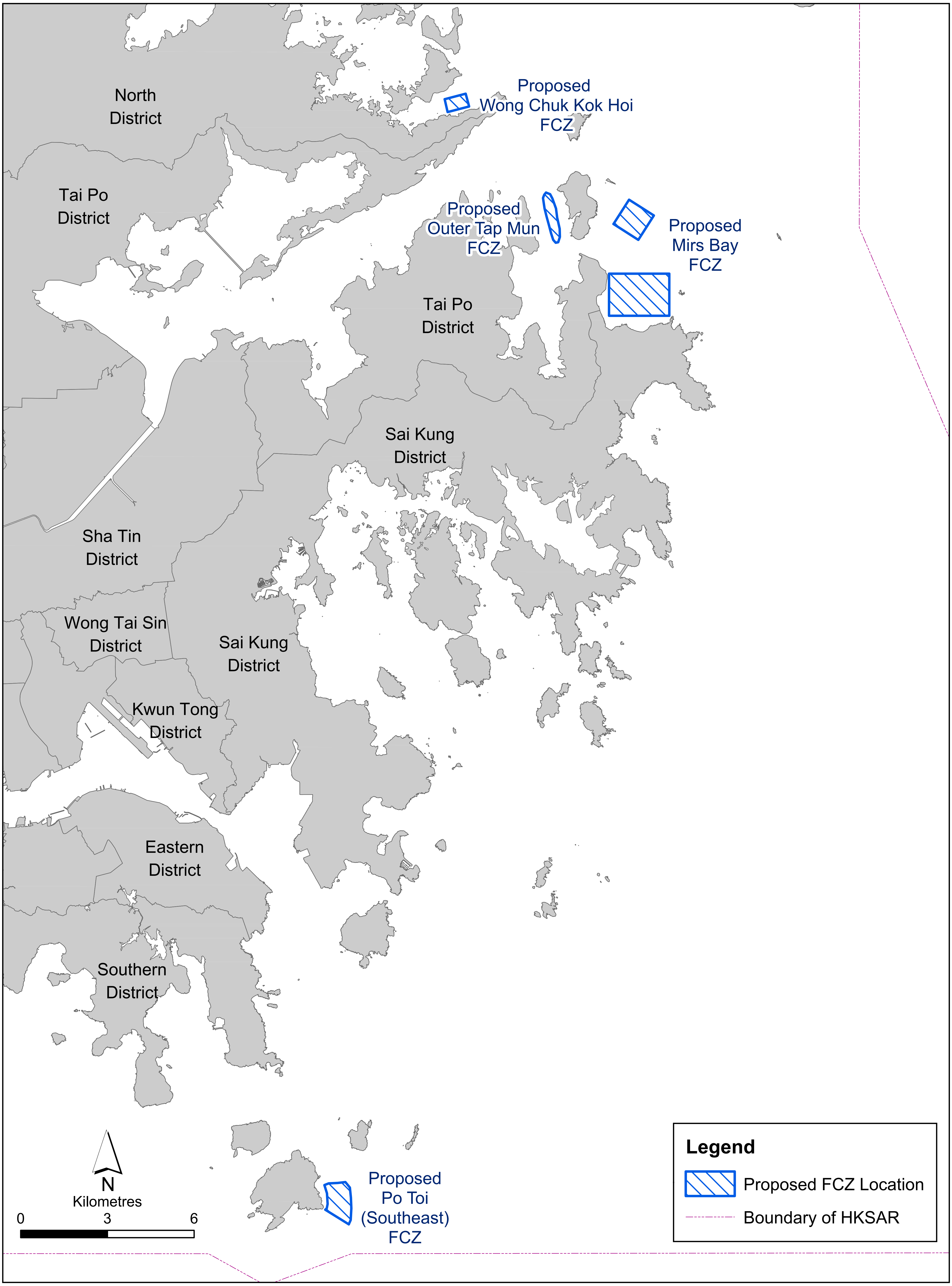


Figure 2.2

Proposed Locations for Establishment of Fish Culture Zones

File: T:\GIS\CONTRACT\0549925\mxd\0549925_Proposed_FCZ.mxd
Date: 18/6/2020

2.5.2 Consideration of the Size and Boundary of the Project Site

The Project site boundary has been designed taking into account the environmental, physical and operational constraints. The Project has been sized to provide sufficient capacity for sustainable mariculture activities without compromising the existing surrounding environment. For instance, the options between the establishment of a single larger FCZ and smaller FCZ at different locations have been considered. While the establishment of a single larger FCZ will concentrate the pollution loading in a particular area, the establishment of small FCZ at different locations will reduce the organic loading and therefore minimise the impact to coral communities and habitat for marine ecological and fisheries resources in the surrounding waters.

Besides, the extent and boundary of the Project site has also been optimized with sufficient clearance to minimise the impacts to coral communities along the coastline, as well as habitats for marine ecological resources and fisheries resources. Meanwhile, sufficient clearance to navigation routes[(4)] has been provided to minimise the potential risk of fish escape and introduction of invasive species to the marine environment due to accidents/ collisions of marine vessels with fish farm facilities. The Project site has also been positioned with a 50 m clearance between the low water mark and the inshore boundary.

2.6 Fish Farm Designs to be Adopted at the Proposed FCZ

A number of different fish farm designs have been considered with regard to the Project site at Outer Tap Mun. Technologies including traditional cages and advanced technologies have been considered. The type of fish farm/ raft to be deployed at the proposed FCZ will be subject to the fish farm operational plan submitted by the future licensees for agreement with AFCD. The advantages and disadvantages of different designs are described below.

2.6.1 Traditional Cages on Rafts

In Hong Kong, the majority of mariculture operations are conducted in traditional cages on rafts. These cages are in an artisanal level, the designs are simple, small and rough (***Figure 2.3***). The raft is built of timber (average size about 180m^2) and is supported by a number of floating units made of empty plastic drums or polystyrofoam floats [(5)]. Net cages (3 x 3 x 3 m) are hung from the raft and the structure anchored to the seabed. Most of the traditional rafts are built on-site, which may lead to waste being released to the sea during the construction. Most of the cages were not tailored made for aquaculture operation purposes. Although these cages are cheaper to build compared to cages used with advanced aquaculture technologies and some recycled materials are adopted as the floating units which has some contribution to waste reduction, traditional cages are not weather resistant and require frequent maintenance and major repairing, which result in more waste generation during mariculture operation. Moreover, these cages cannot withstand swirls caused by typhoon or swift current, therefore, they have to be installed in inshore and sheltered waters, where the water depth is not in favour for the dispersion of pollution loading from mariculture operation. Maintenance dredging and sediment removal maybe required, which will result in adverse water quality impacts and the subsequent ecological and fisheries impacts.

As the Project aims to promote sustainable mode of operation in deeper waters, the traditional cages on rafts are considered technically not suitable and thus is not preferred.

---

(4) Maritime New Zealand (2005) Guidelines for Aquaculture Management Areas and Marine Farms.

(5) Wu RSS and Lee, JHW (1989) Grow-out mariculture techniques in tropical waters: a case study of problems and solutions in Hong Kong. Advances in Tropical Aquaculture Tahiti Feb 20-March 4, 1989. pp.129-136.

Figure 2.3 Example of the Traditional Fish Farms (Source: AFCD)

2.6.2 Advanced Technologies

In order to explore alternative fish farming methods that will support sustainable mode of mariculture operation, advanced technologies have been examined and considered suitable for the Project. Four types of advanced technologies have been considered. The sizes of each type of advanced technologies will be subject to further design based on the operational need proposed by the licensees. The typical dimensions of the floating gravity cages, submersible gravity cages and integrated multi-trophic aquaculture (IMTA) are 50 – 100 m in diameter. The height of the cages will be normally no more than 3 m above water (except during maintenance).

2.6.2.1 Floating Gravity Cage

Floating gravity cage is a simple and common type of cage with a buoyancy collar system and a weighted net enclosure suspended beneath [(6)]. The cage may have walkways around for operation on the cage depending on the design (***Figure 2.4***). The cage has the capacity to withstand wind up to Beaufort scale of 11 (104-117 km/h), wave height of 5 m and current flow of 1.5 m/s [(7)]. In view of Hong Kong being susceptible to typhoon of more than 118 km/h with gusts of more than 220 km/h during summer, the cage is suitable to be used in sheltered to semi-exposed water.

Traditionally, fish cage arrays are orientated with their longest dimension parallel to the predominant current flow to reduce the forces on the mooring systems. However, the most downstream cages will experience reduction in water exchange resulting in lower dissolved oxygen conditions and increased waste loads [(8)]. To maximise water flow, cages should be positioned individually with sufficient separation distances in between. Rows of individual cages should be staggered in relation to one another, and consideration should be given to positioning arrays of cages so that their longest axis is perpendicular to the predominant current direction [(9)].

An example of the floating gravity cage is the HDPE cage system (***Figure 2.5***) that is anti-corrosive, anti-freeze, anti-oxidised, UV-resistant and environmentally friendly. The cage system is widely used in other countries due to the versatility of the materials used and the comparatively limited investment capital required. It is able to withstand sea conditions with strong wind, strong wave and strong water

(6) James MA and Slaski R (2006) Appraisal of the opportunity for offshore aquaculture in UK waters. Report of Project FC0934, commissioned by Defra and Seafish from FRM Ltd. 119 pp.

(7) Qingdao Qihang Fishing Cage Co., Ltd (2016) HDPE Pisciculture Floating Farming Cages.

(8) Klebert P, Lader P, Gansel L and Oppedal F (2013) Hydrodynamic interactions on net panel and aquaculture fish cages: a review. Ocean Engineering 58: 260-274.

(9) Madin J, Chong VC, Hartstein ND (2010) Effect of water flow velocity and fish culture on net biofouling in fish cages. Aquaculture Research 41(10): e602-e617.

currents. It has a long life span of ~15 years without the need of major maintenance. It is also easy to be set up with anchorage system deployed at the corners of the cage.

Figure 2.4 Example of the Floating Gravity Cage (Source: Polarcirkel Plastic Cage)

2.6.2.2 Submersible Gravity Cage

The submersible cage is similar to the floating gravity cage with a buoyancy collar systems and a weighted net enclosure suspended beneath (see ***Figure 2.6***). The design and installation of the cage is similar to the floating gravity cage, but additionally the cage is submersible. The cage can be submerged to a certain depth to avoid damage by wave and swells to protect the cage and the culture fishes during typhoons and adverse weathers while maintaining 90% of its volume [(10)]. The cage has the capacity to withstand wind up to Beaufort scale of 13 (133-149 km/h), wave height of 6 m and current flow of 1.5 m/s [(11)] and is suitable for typhoon prone area. The submergible cage could be submerged underwater to more than 6 m within 15 minutes by lifting devices [(12)]. As the cage is suitable for exposed and typhoon prone area, it could be used in exposed water with higher current flow.

Similar to floating gravity cage, these cages can be made from HDPE material (see ***Section 2.6.2.1***) and should be positioned individually with sufficient separation distances in between. Rows of individual cages should be staggered in relation to one another, and consideration should be given to positioning arrays of cages so that their longest axis is perpendicular to the predominant current direction [(13)]. As the cage is to be used in exposed water with higher current flow, mariculture activities will be conducted with the help of support vessels.

(10) 沅江市福利渔网 (2013) 深海养殖网箱.

(11) Qingdao Qihang Fishing Cage Co., Ltd. (2016) HDPE Pisciculture Floating Farming Cages.

(12) Qingdao Qihang Fishing Cage Co., Ltd. (2016) Aquaculture Submergible Cage.

(13) Madin J, Chong VC, Hartstein ND (2010) *Op. Cit.*

Overview of High-Density Polyethylene (HDPE) Cage System

(Source: Qingdao Qihang Fishing Cage Co., LTD)

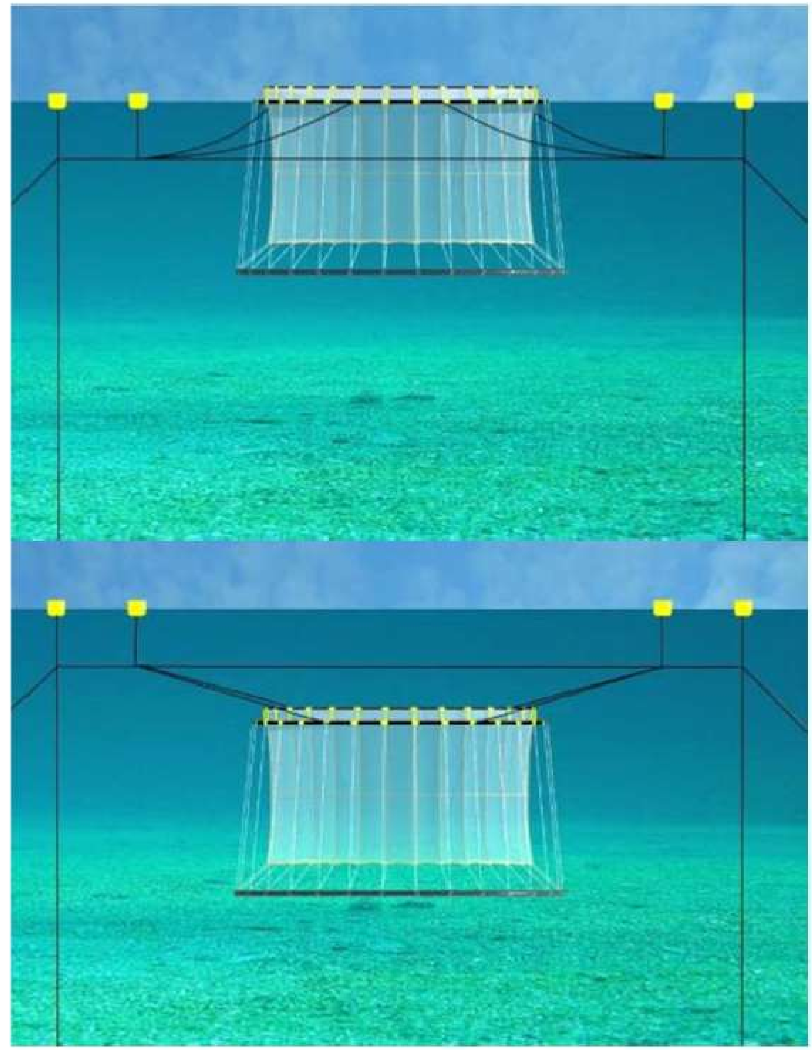


Illustration of HDPE Floating and Submersible Cage System

(Source: https://www.linkedin.com/pulse/offshore-aquaculture-submersible-hdpe-cages-oceanis-1-ciattaglia)

Figure 2.6 Example of Submersible Cage for Fish Culture (Source: Qingdao Qihang Fishing Cage Co., LTD.)

2.6.2.3 Integrated Multi-trophic Aquaculture (IMTA)

The IMTA involves the culture of fish in combination with organisms of different trophic levels that utilise waste particulates and dissolved nutrients could be promoted for the new FCZs (***Figure 2.7***). The filter feeders and deposit feeders cultured with fish stocks not only could utilise excessive waste generated by uneaten fish feeds and mariculture operations, but these species, if economically valuable, would increase the economical return as well as reduce environmental impact caused by mariculture operations.

2.6.2.4 Culture Species

The following criteria shall be considered when determining the species to be cultured together with the fish stocks and some of the proposed organisms and example species are shown in ***Table 2.3***:

- The availability of seed stocks from hatchery, preferably sourced from a captive brook stock to reduce pressure in catching wild population;
- Native species is preferred to prevent the spread of invasive, exotic species that may threaten the local ecosystems; and
- Species with higher economic value to attract interest in the application of IMTA in mariculture operations.

Table 2.3 Proposed Organisms and Example Species for IMTA

Category	Organisms	Examples	Reason
Deposit Feeders	Sea urchins	Collector urchin (*Tripneustes gratilla*) Purple sea urchin (*Anthocidaris crassispina*)	High economic value and native species of Hong Kong.

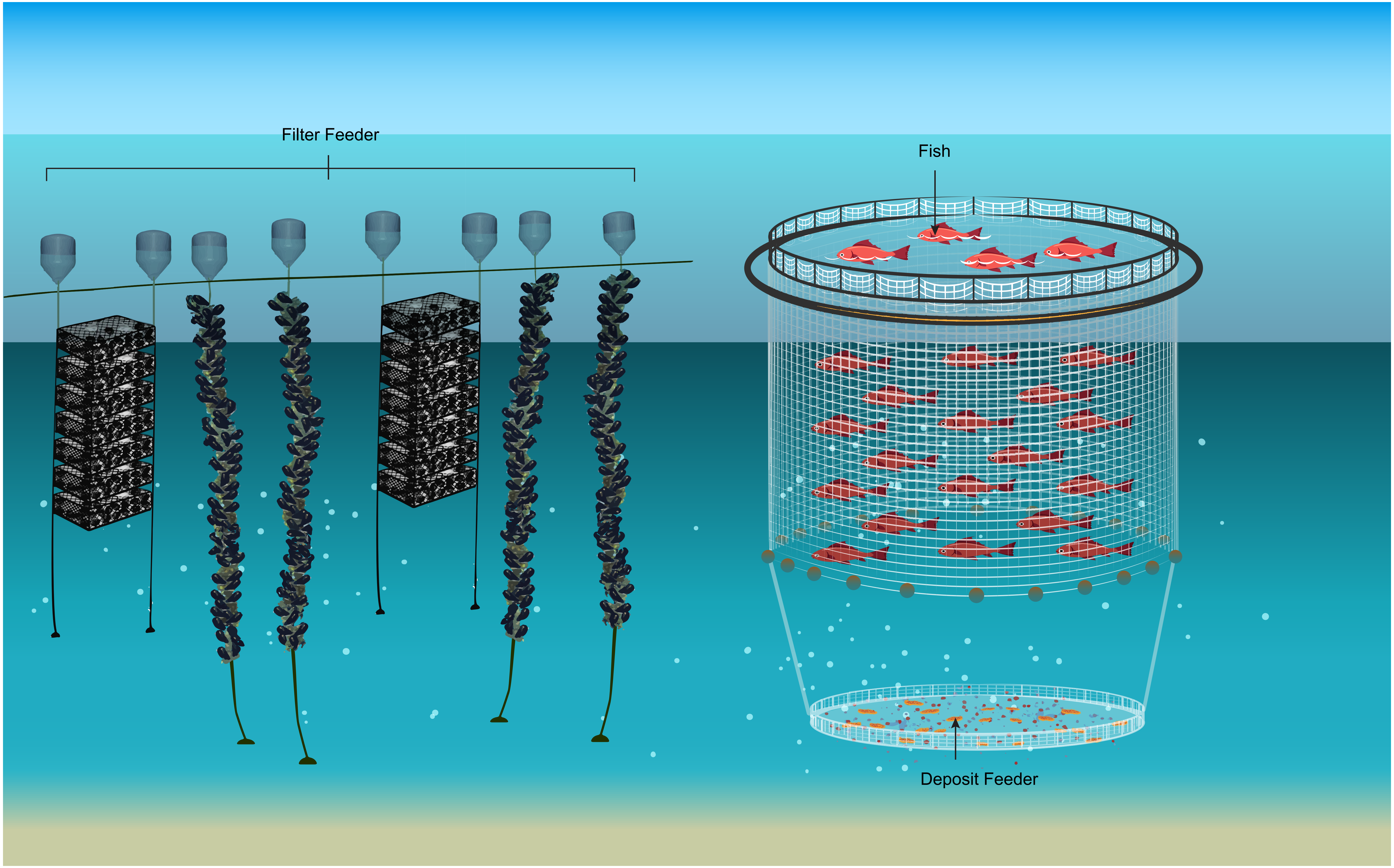


Figure 2.7

Sample Layout of IMTA

Category	Organisms	Examples	Reason
	Sea cucumbers	Japanese spiky sea cucumber (*Apostichopus japonicas*)	No common species in Hong Kong but are of high commercial value. This species is commonly farmed in China and well known about its delicacy and its medicinal properties.
	Lobsters	*Panulirus homarus*	Commonly farmed and of high economical value.
Filter feeders	Mussels	Green-lipped mussel (*Perna viridis*)	Native species and an adult green-lipped mussel can filter 30 L of seawater per day. However, it is of relatively low economical value.
	Scallops	*Chlamys farreri, Argopecten irradians*	Commonly farmed in China and of high economical value.
	Abalones	*Haliotis discus*	Commonly farmed and of high economical value.

2.6.2.5 Configuration and Design

Submerged bottom cages with deposit feeders (e.g. sea cucumber, sea urchin) could be positioned on the seabed or under the cage to allow the organisms to feed on waste generated by the mariculture operations. Studies have shown that sea urchins and sea cucumbers have high assimilation efficiency of fish wastes (14) and grew significantly faster under fish farms than at control sites (15) (16). Tailor-made submerged cage for sea cucumber culture is available and capable of being submerged to a depth of up to 30 m and withstanding wind of 12 Beaufort scale (118 – 132 km/h). The cages should be positioned under or in close proximity of the cage.

Longline culture or lantern nets hung vertically from lines are suitable for culture of bivalves. It is considered that lantern nets are preferable under sheltered conditions while longlines are preferred under exposed conditions (17). The longline or lantern nets should be placed in close proximity to the cages (e.g. within 50 m) (18). Sample arrangement of IMTA design is presented in ***Figure 2.7***. Examples of submerged cages and lantern nets are shown in ***Figure 2.8*** and ***Figure 2.9***. IMTA is commonly used in open water areas of Fujian and Shandong provinces in mainland China (19).

(14) Nelson EJ, MacDonald BA and Robinson SMC (2012) The absorption efficiency of the suspension-feeding sea cucumber, *Cucumaria frodosa,* and its potential as an extractive integrated multi-trophic aquaculture (IMTA) species. Aquaculture 370-371: 19-25.

(15) Ahlgren MO (1998) Consumption and assimilation of salmon net pen fouling debris by the red sea cucumber *Parastichopus californiens*: implications for polyculture. Journal of the World Aquaculture Society 29(2): 133-139.

(16) Cook EJ and Kelly MS (2007) Enhanced production of the sea urchin *Paracentrotus lividus* in integrated open-water cultivation with Atlantic salmon *Salmo Salar*. Aquaculture 273(4): 573-585.

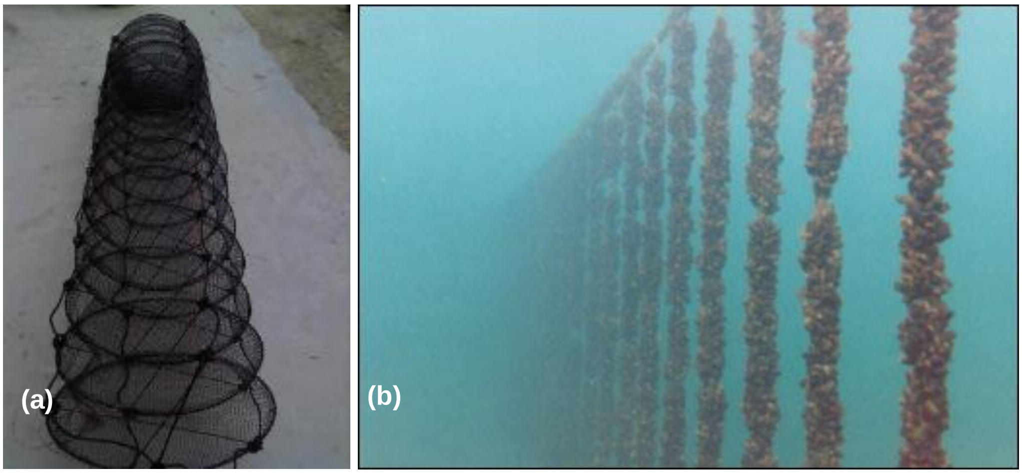
(17) BC Shellfish Grower's Association (n.d.) Longline Culture Systems.

(18) Chopin T, Robinson SMC, Troell M, Buschmann AH and Fang J (2008) Multitrophic Integration for Sustainable Marine Aquaculture. Ecological Engineering. Elsevier. pp.2463-2475.

(19) Dong, S., Fang, J., Jansen, H.M. & Verreth, J. 2013. Review on integrated mariculture in China, including case studies on successful polyculture in coastal Chinese waters. Workpackage 3: support the application of integrated multi-trophic aquaculture (IMTA). ASEM Aquaculture Platform, Seventh framework programme.

Figure 2.8 Example of Deep Cage for Echinoderm Culture (Source: 青岛利东海洋网箱科技有限公司)

Figure 2.9 Examples of (a) Lantern Nets and (b) Longlines for Bivalve Culture (Source: Qingdao Mansheng Industry and Trade Co., Ltd., Department of Fisheries and Oceans)



2.6.2.6 Semi-submersible Steel Truss Cage

In 2021, AFCD has established a modern mariculture demonstration farm at Tung Lung Chau FCZ with the use of the semi-submersible steel truss cage fish farm design (***Figure 2.10***). The dimensions of this cage are about 91 m in length, 28 m in width and 7.5 m in depth, with a design draft of about 6.5 m (20). The height of the cage (i.e. from the tip of the truss structure to the water surface) is about 3 m above water (except during maintenance). It is composed of a main structure in all-welded steel, connected to four floating steel ballast tanks. It uses a five-point mooring system to secure the farm in the designated location with three main cages which the culture nets are fixed to the main steel structure. The level in which the cage can be partially submerged is adjustable to avoid damage by

(20) AFCD (2021) Press Release - AFCD sets up modern mariculture demonstration farm.

wave and swells to protect the cage and the cultured fishes during typhoons and adverse weather. The effective mariculture water volume is about 11,000 m^3. The cage has the capacity to withstand wind up to Beaufort scale of 17 (202-220 km/h), wave height of 9 m and current flow of 1 m/s and is suitable for typhoon prone area. As the cage is suitable for exposed and typhoon prone area, it could be used in exposed water with higher current flow. In addition, this cage is equipped with modernised technology and management, such as a real-time surveillance system, a real-time water quality monitoring system, an automated feeding system and a solar and wind power generation system.

Similar to floating gravity cage, these cages should be positioned with sufficient separation distances with other cages in the vicinity. The cages should be staggered in relation to one another, and consideration should be given to positioning arrays of cages so that their longest axis is perpendicular to the predominant current direction (21). As the cage is to be used in exposed water with high current flow, mariculture activities will be conducted with the help of support vessels.

Figure 2.10 Example of Semi-submersible Steel Truss Cage (Source: AFCD)

2.6.3 Environmental Benefits of Modern Fish Farm

Overall, modern fish farm with advanced technologies have the following environmental benefits:

- Fish farm components are prefabricated offsite which reduces construction activities and duration onsite and hence impacts to the surrounding environment;
- Use of technology (e.g. real-time surveillance and water quality monitoring, renewable energy sources such as solar and wind) and automation (e.g. fish feeder) can reduce labour intensive activities, hence reduce potential disturbance to ecology and environment from feed wastage, workforce wastes, vessel trips, etc.;
- Cages made of weather-resistant materials such as high-density polyethylene (HDPE) and steel truss cages are more durable and of good quality, less likely to be damaged or repaired with less waste generation;
- Submersible/ semi-submersible fish cages are designed to endure adverse weather conditions. Fish loss/ escape due to cage/raft damage can therefore be minimised and potential impact of introduction of invasive species on local ecology and fisheries could be reduced. Besides, the need for temporary relocation of fish raft due to adverse weather is also reduced and therefore reducing the associated potential impact;
- Separation distance between fish cages and between the cage bottom and seabed would be maintained to allow adequate water flow in between and reduce impacts on water quality such

(21) Madin J, Chong VC, Hartstein ND (2010) *Op. Cit.*

as changes in flow regime and build-up of organic content, reducing the subsequent ecological and fisheries impacts in the vicinity and degradation of the nearby marine environment;

- These sizable cages can avoid overcrowding of fish stock, and with good mariculture practice and dispersion by the open sea, organic content is not built up on the seabed. Maintenance dredging and sediment removal are therefore not required for FCZ in deep waters, and the associated water quality impacts and related ecological and fisheries impacts can be avoided; and
- Fish farm structures have the potential to provide artificial substrates for marine organisms to colonise and build diverse and functional habitats.

All four types of advanced technologies are considered suitable and preferable for the new FCZ and the environmental performance of each type of advanced technologies is similar. Given the mariculturists will culture fish within the maximum allowable stock as specified in the licence condition, there will not be significant difference in assessing the worst-case scenario in terms of pollution loadings when adopting different type of advanced mariculture cages/ raft designs. The mariculturists will propose any of the advanced technologies for mariculture operation within the Project site to suit their business need for agreement with AFCD.

2.7 Consideration of Construction Methods and Sequence

With the use of advanced mariculture technologies, a majority of the framework of the fish cages will be prefabricated off-site, and then tow the fish farm framework to the Project site for assembly and anchorage. It is in fact unlikely that this more advanced type of deep-water mariculture can be completely assembled from raw materials on-site and there is no alternative construction method. Prefabrication work off-site can minimize the construction duration on-site and hence reducing the duration when potential impacts to the environment can occur. It is expected to avoid generation of C&D materials and potential water quality impact from construction site run-off during the construction of the Project. Generation of underwater sound is minimised in this method, with less disturbance to marine and fisheries habitats. Also, less labour input required on site would result in reduction of waste generated from human activities.

2.8 Summary of Development Options

Viable sites of the Project have been considered during the Project's Feasibility Study, based on the environmental benefits and dis-benefits for the construction and operation of the new FCZs. Various development options are reviewed and considered in the EIA study. The environmental benefits and dis-benefits of the development options are summarised in ***Table 2.4***. Outer Tap Mun is one of the proposed sites which met the selection criteria for new FCZs and is sited to avoid encroaching sensitive receivers (e.g. ecologically important habitats, areas of high fisheries importance). To further minimise potential impacts, the Project site will adopt modernized and advanced type of aquaculture technologies and operate within the maximum standing stock as identified in this EIA study.

Table 2.4 Summary of Environmental Benefits and Dis-benefits of the Development Options and Alternative Mitigation Measures Considered for the Project

Development Options	Benefits	Dis-benefits
Project Siting		
<u>Preferred Option</u> Site selection of sustainable mariculture with reference to international guidelines, which include minimum water depth, wave exposure, water quality and the compatibility with the existing usage and environment	▪ Avoid encroaching into ecological sensitive receivers e.g. marine reserves, coral habitats of high ecological value and areas of high fisheries importance, thus avoid impacts to marine ecology and fisheries ▪ Better water flushing rate for mariculture to allow adequate water dispersion and prevent the build-up of organic content and degradation of the nearby marine environment. Consequently, organic content is also not built up on the seabed and maintenance dredging and sediment removal are therefore not required for FCZ in deep waters, and the associated water quality impacts and related ecological and fisheries impacts can be avoided ▪ Remote area at Outer Tap Mun minimises impacts on air quality, noise, and visual sensitive receivers	▪ May pose potential environmental impacts to newly affected areas. However, careful site selection and fish farm design have been done to avoid / minimise potential impacts
<u>Alternative Option</u> Expanding existing FCZs	▪ Limit environmental impacts to areas that are already affected by existing FCZs	▪ Development constrained by existing marine usage and nearby ecological sensitive receivers. Water flushing rate is generally lower due to inshore and shallow waters of the existing FCZs. Impacts to water quality, including restricted dispersion and accumulation of organic loading due to FCZ operation, are likely to occur when more mariculture production is necessary to support the development of mariculture in Hong Kong. ▪ Sediment removal may be required periodically to maintain a suitable environment for mariculture. The environmental impacts are likely to be more detrimental

Development Options	Benefits	Dis-benefits
		for FCZs in inshore areas with shallow water depths. Alternative mitigation measures such as deployment of silt curtain and control of dredging rate, etc would be required to minimise the water quality and marine ecology impact.
Project Size / Scale		
Preferred Option Establishment of smaller FCZ at different locations	▪ Establishment of smaller FCZs to reduce the organic loading at individual site, to minimise impact to coral communities and habitat for marine ecological and fisheries resources. ▪ With sufficient clearance to navigation routes, accidents / collision of marine vessels with fish farm facilities, and potential risk of fish escape and introduction of invasive species to the marine environment can be minimised.	▪ Affect more areas with potential environmental impacts but better control of impact intensity to within relevant criteria
Alternative Option Establishment of a single larger FCZ	▪ Limit environmental impacts to single location but with higher intensity	▪ The pollution loading from mariculture operation will concentrate in a particular area. The potential impacts to water quality, marine ecology and fisheries of the surrounding waters are expected to increase.
Fish Farm Layout and Design		
Preferred Option Use of advanced mariculture fish farm designs (e.g. HDPE cages, steel stuss cages)	▪ Durable and weather-resistant material would less likely to get damaged or repaired and result in less waste generated. ▪ Less susceptible to damage during adverse weather condition, such as typhoons, and minimise potential risk of fish loss / escape, and subsequent impact on local ecology and fisheries; and also minimise impact due to fish cage relocation.	▪ Higher setup cost

Development Options	Benefits	Dis-benefits
	▪ Adequate water flow and dispersion of organic content between cages / rafts, and along the water column is allowed. Adequate clearance from seabed will also be maintained. Water quality impacts such as changes in flow regime and build-up of organic content are minimised. Subsequent ecological and fisheries impacts in the vicinity and degradation of the nearby marine environment could be reduced. The need for maintenance dredging and sediment removal during construction and operation of the Project is also avoided. ▪ Use of green technology and automation could reduce feed wastage and physical labour, hence reduce potential disturbance to water quality, ecology and environment from feed wastage, workforce wastes, vessel trips, etc.	
<u>Alternative option</u> Use of traditional fish farm designs (e.g. made of timber supported by floating units made of empty plastic drums or polystyrofoam floats)	▪ Lower setup cost	▪ Non-weather resistant materials and easy to get damaged or repaired. More wastes are expected to be generated. ▪ Susceptible to damage from adverse weather conditions such as typhoons. Potential risk of fish loss / escape is higher, and subsequent impact on local ecology and fisheries; and also impact due to fish cage relocation would increase. ▪ Potential impact on water flow and dispersion of organic content between cages / rafts, and along the water column might be present, and result in the build-up of organic content on seabed. Maintenance dredging and sediment removal may be required periodically and water quality impacts would arise. Subsequent ecological and fisheries impacts in the vicinity and

Development Options	Benefits	Dis-benefits
		degradation of the nearby marine environment would also increase. Other mitigation measures will be required to control and minimise impacts to water quality, such as the use of silt curtains, closed grab dredger, etc. ▪ Require more labour input and hence increase potential disturbance to ecology and environment from feed wastage, workforce wastes, vessel trips, etc.
Construction Methods and Sequence of Works for the Project		
<u>Preferred option</u> Fish farm framework are pre-fabricated off-site, then assemble and anchored on-site	▪ Minimisation of construction duration on-site and hence reducing the duration when potential impacts to the environment can occur. ▪ No generation of C&D materials on-site and potential water quality impact from construction site run-off during the construction of the Project is avoided. The use of silt curtain and construction boats for silt curtain deployment are therefore not required, the subsequent impacts to marine and fisheries habitats such as underwater sound from marine vessels are minimised ▪ Less labour input required on site would result in reduction of waste generated from human activities	▪ N/A
<u>Alternative option</u> No alternative option applicable as the fish farm framework used for advanced type of mariculture is large in scale, and could not be constructed from raw materials on site.	▪ N/A	▪ N/A

2.9 Details of the Project

After the designation of the new FCZ, AFCD will grant new marine fish culture licences to mariculturists who applied. The Project will then involve fish raft and cages construction and culture operation by the licenced mariculturists. No land-based works are involved in the Project, and no land will be taken by the Project.

2.9.1 Design and Configuration

Separation distance will be maintained between fish rafts / cages, as a condition in the licence to be issued to mariculturists by AFCD, primarily aimed at reducing any potential biosecurity risk caused by disease and mortality of fishes. The sufficient separation distance could also help to maintain adequate water flow within the FCZ as well as allow access to individual fish cage by vessels. For example, typical separation distance of around 100 m will be provided between each fish rafts / cages with typical size around one hectare of sea area. The detailed number, size and separation distance of the fish rafts / cages would be determined by the applicant at a later stage and agreed with AFCD.

There will also be communal rafts for mutual use amongst licensees within the Project site. Water monitoring equipment would be installed by AFCD at the Project site for real-time monitoring of water quality, including dissolved oxygen, turbidity, etc. The licensees could make use of the water quality data to determine if any precautionary measures should be conducted, e.g. additional air pumping, fish stock relocation. In addition, the communal raft can also be used as a supply base for keeping pellet feed and other common operational utility/equipment for the licensees within the FCZ. The communal rafts are not for living purpose. All of the facilities will be controlled under the licence to mariculturists.

2.9.2 Construction Activities

For all types of advanced aquaculture technologies, the construction of the proposed Project will mainly involve the setup of fish farm structures, including fish rafts / cages, auxiliary facilities (such as storage areas on communal rafts) and mooring system at sea. No land-based works, structures and activities are involved in the Project and no landscape areas will be affected. The scale of construction work on-site is relatively small and the installation of fish farm structures are expected to be completed within a few weeks for each fish raft. Main components of the rafts / cages are manufactured off-site and will be towed to the Project site using tug boat. On-site assembly and anchoring of the fish rafts / cages will be assisted by a small number of marine vessels such as sampans and small speed boats for up to a few trips per day. These vessels will be the major means of transport to the Project site during the construction phase and anchoring of these vessels might be required. No dredging works are required during the construction phase and no heavy construction plant would be used. Fish rafts / cages and auxiliary facilities, such as storage space and shelters, will be positioned by anchor lines attaching to the anchorage points on the seabed. Use of winch might also be required during the assembly and anchorage of fish rafts / cages. All construction activities shall be conducted during daylight hours.

2.9.3 Operation Activities

Mariculture activities, such as management of fish raft / cages and fish stocks within the Project site at sea will be undertaken during operational phase with all types of advanced technologies. No land-based works, structures and activities are involved in the Project and no landscape areas will be affected. Limited numbers of small power generators will be used on fish rafts to support daily mariculture activities. The transportation of fish stocks, fish feed, fish raft equipment and workforce as well as occasional visitors will make use of mainly small marine vessels such as sampans and speed boats for a few trips a day. These vessels will be the major means of transport to the Project site during operation phase. As the fish farm facilities will be used mainly for mariculture, auxiliary facilities such as storage space and shelters will be present, and automated / remote fish feeder machines will be adopted in the Project to reduce physical labour input. There will be no facilities to support on-site living and activities such as cooking is not anticipated at the Project site. No maintenance dredging or sediment removal will be required during FCZ operation.

2.9.3.1 General Management of the FCZs

Mariculture in Hong Kong is protected and regulated by the *Marine Fish Culture Ordinance (Cap. 353)* which states that a person should have the required license to be engaged in fish culture within a fish culture zone and the fish culture zone should be used for mariculture purposes only. This will help to restrict the types of activities that would occur within the FCZ and restrict sources of water pollution to fish farms and associated marine vessels. The general management of the new FCZs therefore shall follow the *Marine Fish Culture Ordinance (Cap. 353)* and *Marine Fish Culture Regulations (Cap. 353A)*.

Mariculture rafts made of more durable materials (e.g. HDPE, steel truss cages) will be encouraged during the approval process by AFCD for licence in the Project site. AFCD will issue licences to the successful applicants (“licensees”) with specific terms and conditions. Licensees would be required to submit a fish farm operational plan to AFCD under the *Marine Fish Culture Ordinance (Cap. 353)* during the application of the fish culture licence, aiming to implement good site practices and prevent impacts on the environment. Licensees should, for example, ensure that the mesh size and quality of the nets will provide a complete barrier to retain fish stocks within cages and free from holes to prevent fish escape, the design of the cages can prevent fish stocks from “jumping” out of the cage, and cages (except cages used for the cultivation of deposit feeders for IMTA) will be positioned and securely anchored to have at least 2 m clearance from the seabed at all times to avoid impacts to the seabed and allow sufficient water exchange within the cage. Licensees should ensure their rafts and cages have the ability to withstand adverse weather conditions (e.g. typhoon) by using cage types with appropriate anchors and moorings. Licensees are required to operate machinery in a manner that minimise disturbance to the seabed. AFCD will conduct regular inspection and review on FCZ operation to determine substantial use of the licensed area and consider the renewal of licenses where applicable. Performance criteria will be monitored and audited for the mariculture operations to ensure the appropriate use of the licensed area and the implementation of proper fish farm management. When licensees do not comply with the licence conditions, the licence may be suspended or revoked.

Operation practices and measures to be adopted in the Project are listed in ***Appendix 2A***.

2.10 Tentative Implementation Programme

Subject to the completion of this EIA study and issuance of EP, legislative exercise will be carried out to amend the *Schedule to the Fish Culture Zone (Designation) Order (Cap. 353B)* by negative vetting for designating new FCZ. Consequential amendments to other related ordinances will also be made as necessary. After the designation of the new FCZ tentatively in Year 2023, AFCD will grant new marine fish culture licences to mariculturists who successfully apply to operate in this FCZ.

Construction activities by licensees are expected to commence in Year 2024, subject to the timing of application and approval of the new marine fish culture licence. The construction period of the Project, i.e. from the commencement of the on-site construction and installation works until the new FCZ has reached its design capacity, will be subjected to future application and approval process. Typically, the construction, transfer, and on-site assembly and anchorage of a modern fish raft / cages with ancillary facilities will take a few weeks to complete.

Mariculture operation is expected to be commenced by stages upon complete installation of fish farm by individual mariculturist. Modern design fish farm, depending on the material adopted, would typically last for over 10 years without major repair.

2.11 Interactions with Other Surrounding Projects

The Project may have the potential to interact with the proposed establishment of FCZs at Wong Chuk Kok Hoi and Mirs Bay, subject to the timing of completion of legislative exercise to amend the *Schedule to the Fish Culture Zone (Designation) Order (Cap. 353B)* and existing FCZs in the vicinity. No other existing or committed project is identified in the vicinity of the Project site, which may potentially interface with the construction and operation of this Project. Cumulative impacts due to the proposed establishment of FCZs at Wong Chuk Kok Hoi and Mirs Bay and existing FCZs in the vicinity have been addressed in the relevant technical assessments in this EIA study as appropriate.