Environmental Impact Assessment ("EIA") for a Proposed Integrated Development at Marina Coastal Drive

The Maritime and Port Authority of Singapore (MPA) plans to develop an integrated development to house maritime decarbonisation related research and development ("R&D"), test-bedding facilities for decarbonisation technologies, start-ups, and other maritime R&D activities to promote maritime decarbonisation efforts in Singapore. The integrated development will consist of buildings and marine jetties. An EIA has been carried out to determine the impact of the proposed integrated development and to recommend mitigation measures.

The EIA report will be available for public feedback from 1 September 2022 to 29 September 2022 and will continue to be available for public viewing on MPA's website at https://go.gov.sg/eia-marinacoastaldrive with effect from 1 September 2022.

MPA will consider all relevant public feedback before finalising the development plans for the integrated development. Please contact Ms. Cheong Yiting or Mr. Lim Chu Rui via email at Cheong_Yiting@mpa.gov.sg or Lim_Chu_Rui@mpa.gov.sg, respectively, for information or to give feedback.

Environmental Impact Assessment for a Proposed Integrated Development at Marina Coastal Drive

Environmental Impact Assessment (EIA) Report

Final Report





Maritime and Port Authority Singapore

Environmental Impact Assessment (EIA) Report

April 2022

This report has been prepared under the DHI Business Management System certified by Bureau Veritas to comply with ISO 9001 (Quality Management), ISO 14001 (Environmental Management), ISO 45001 (Occupational Health and Safety Management) and bizSAFE STAR

Environmental Impact Assessment for a Proposed Integrated Development at Marina Coastal Drive

Environmental Impact Assessment (EIA) Report

Final Report

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1 Introduction

DHI Water & Environment (S) Pte Ltd (DHI) has been engaged by Maritime and Port Authority of Singapore (MPA) for the ***Provision of Consultancy Services for an Environmental Impact Assessment (EIA) for a Proposed Integrated Development at Marina Coastal Drive (Study).***

The Study is comprised of the following scope of services:

- Biodiversity surveys for the subject site, which includes the followings:
  - Preliminary surveys
  - Baseline surveys
  - Engagement of blue group(s) for both preliminary surveys and baseline surveys
- Assessment of the impact of the development on the biodiversity, which includes the followings:
  - Development of mitigation measures which might include planning of coral relocation to be carried out by the construction contractor, if it is deemed that the corals will be negatively impacted by the development
  - Development of Environmental Monitoring and Management Plan (EMMP)
- Public disclosure

1.1 Project Overview

Maritime and Port Authority Singapore (MPA) is planning to develop an integrated facility to house maritime decarbonisation related Research and Development, test-bedding of decarbonisation technologies, start-ups, and other Maritime R&D activities to promote Maritime decarbonisation effort in Singapore. The integrated facility involves on the land side, building construction and on the sea side, marine jetties. Some new jetties and a piled deck wharf along the 330m length of shoreline extending to the east from Marine South Pier will be constructed (Figure 1.1).

The jetty and wharf construction will involve piling works. The water depths at the jetty berths should be sufficient for the relatively shallow draft vessels that are planned to use the jetties, so the capital dredging is not expected for the jetties.

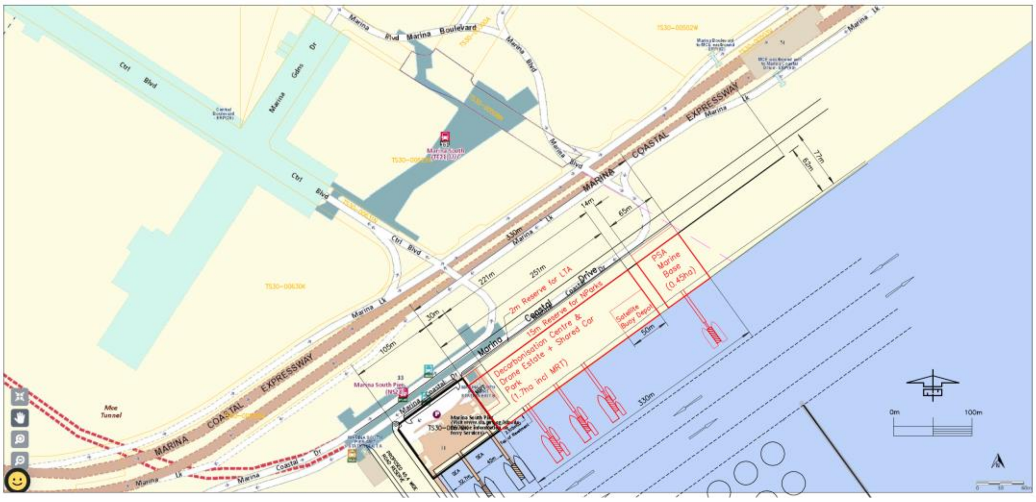


Figure 1.1 Indicative locations for new jetties and wharf at Marina South (red outlines)

This Study is for the purpose of obtaining the planning approval for the Development. Based on pre-consultations with relevant agencies, there is no landside receptor as the site is an early reclaimed land temporally used as tree nursery before it is released for other long-term uses. The proposed construction will alter the coastline along the 330m coastline adjacent to the east of Marina South Pier. There are possibly corals along the shorelines of the development site which will be the focus of this EIA Study.

2 Regulatory Processes and Legislation

2.1 EIA Procedures in Singapore

Singapore adopts a systematic framework to determine and mitigate the potential impact of any new development on the environment. Environmental considerations are an important part of the planning evaluation process, and planning approvals are granted to development proposals only when they have met the requirements imposed by the relevant regulatory agencies. If the impact on the environment could be significant, an environmental study will be required to assess in greater detail the full impact and develop more extensive mitigating measures.This study was carried out according to the local EIA process as illustrated in Figure 2.1 and summarized in Table 2.1. Note that Screening step has been conducted by MPA before DHI's commencement of this study, outcomes of which are documented in Section 3.

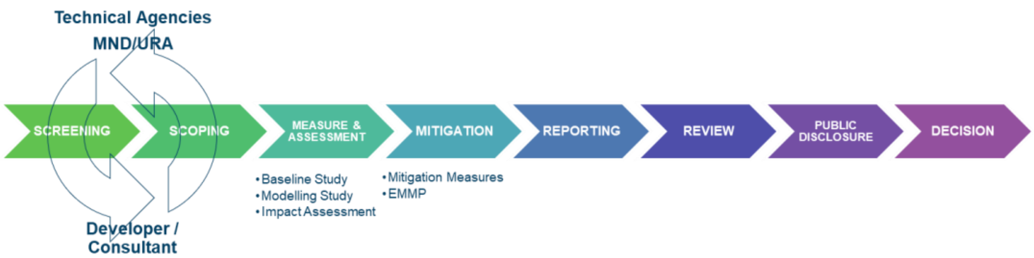


Figure 2.1 An illustration of EIA procedures in Singapore. Stakeholder engagement is project dependent and can take place at various stages of the study.

Table 2.1 Objectives of key EIA stages in Singapore

EIA Stage	Objectives
Screen	To identify and recommend whether or not an Environmental Impact Assessment is required and propose a stakeholder engagement plan for the Project.
Scope	To identify environmental pressures/changes arising from the Project and environmental sensitive receptors (ESRs) that may be affected by them and on that basis, determine assessment scope (spatial and temporal boundaries, impacts to be assessed) and formulate EIA approach and methodology.
Measure	To describe the baseline conditions and the identified ESRs in potential impact zone of the Project, either through field surveys or desktop literature searches and data analysis.
Assess	To classify significance of impacts through assessment of magnitude and duration of environmental pressures in relation to tolerance limits of the ESRs, taking into account the importance of the receptors and their recoverability from the impacts.
Manage & Mitigate	To outline management and engineering measures are required to mitigate the impacts to an as-low-as-reasonably-practicable level (ALARP) and monitoring regime for construction phase to ensure that impacts are managed accordingly.
Report & Consult	To prepare and submit the Environmental Impact Assessment Report; consultation (with the TAs and the public); and decision-making by URA and MND.
Engage	To engage relevant stakeholders (socio-economic receptors, interest groups, etc.) to obtain feedback on scoping, impact findings and monitoring requirements – stakeholder engagement requirement varies depending on scale of development, sensitivity of the project area, among other factors.

2.2 Key Agencies and Stakeholders / Blue Groups

As part of the local EIA process, coordinating agencies Urban Redevelopment Authority (URA) and Ministry of National Development (MND) and the four technical agencies - National Environment Agency (NEA), Singapore Food Agency (SFA) and Maritime and Port Authority (MPA) was engaged for the environmental screening process (Section 3.1). For the purpose of this study, the key agencies to address are identified as below:

- MPA – Maritime and Port Authority (Port Masters' and other Departments). Developer Agency (DA) for the proposed development works in this study.
- NParks – National Parks Board. One of the technical agencies in the planning approval process.
- URA – Urban Redevelopment Authority. Coordinating agency for the planning approval process.

The following stakeholders / blue groups have been identified for the private and NGO sector in consultation with NParks.

- NUS Reef Ecology Lab
- NUS Experimental Marine Ecology Lab
- St. John's Island National Marine Laboratory (SJINML)
- Nature Society Singapore (NSS) – a non-government, non-profit organisation dedicated to the appreciation, conservation, study and enjoyment of the natural heritage in Singapore, Malaysia and the surrounding region.
- WildSingapore
- Friends of Marine Park
- Our Singapore Reefs
- Singapore Blue Plan 2018, NUS

2.3 Applicable Legislation, Laws and Standards

There is a selection of regulations and laws that are of relevance to the execution of the environmental feasibility and the subsequent EIA analyses. In addition to the above-mentioned applicable regulations, national goals or strategies and ratified international conventions are also of relevance to the legal framework. The aforementioned environmental legislation, as well as other relevant laws, existing acts and guidelines seen as 'environmentally' relevant are discussed in Section 2.3.1 and 2.3.2.

2.3.1 Relevant Singaporean Acts

Several Singaporean Acts are applicable to this study. These include, but are not limited to, the following:

- Planning Act (revised 1998). An act to provide for the planning and improvement of Singapore and for the imposition of development charges on the development of land and for purposes connected therewith.
- Wildlife Act 1965 (revised 2020). Covers the protection of wildlife. Implemented by NParks
- Fisheries Act 1966 (revised 2002). Covers conservation and protection of fisheries resources. Implemented by SFA

2.3.2 Applicable International Guidelines and Other Evaluation Criteria

Other internationally accepted policies and guidelines may be referenced and applied as a basis for assessing impacts. The following, amongst others, have been identified for this project:

- UN Convention on Biological Diversity 1992.
- IUCN Red List of Threatened Species for assessing the vulnerability of species. Under this classification scheme, globally threatened species have been categorised

as Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened or Least Concern;

- Singapore Red Data Book (NParks, 2021) for assessing the vulnerability of species in Singapore. Under this classification scheme, locally threatened species have been categorised as Globally Extinct, Presumed Nationally Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened or Least Concern;

It should be noted that this list is not exhaustive, and specific standards and guidelines may be referenced throughout the relevant sections of the EIA Report.

2.4 Limitations of Report

This EIA Report has been prepared for use by MPA in accordance with the agreement under which DHI's services were performed, assessing the potential impacts arising from the construction activities. DHI does not accept any liability if the information, assessments or professional advice contained in this Report are used for any other purpose except the agreed purposed of assessing the Project's impact on the environment, as part of URA's planning approval process.

Where field investigations have been carried out, these have been carried out to the level of detail required to achieve the objectives of this assessment. The results of any measurements taken may vary spatially or with time and further investigations should be made after any significant delay in using this report.

Unless otherwise stated in this report, the assessments assume that the site and/or facilities will continue to be used for their stated purpose without significant change.

Whenever the above limitations occurred, appropriately supported assumptions were made to ensure that undertaken analyses provided sufficiently representative impact analyse results.

3 Screening and Scoping

3.1 Environmental Screening

Based on Technical Agencies' assessment, MND/URA concurred with the assessment that an Environmental Study is required to evaluate the impact of the proposed work, with focus on the biodiversity related components. The Developing Agency is to conduct baseline biodiversity study and impact assessment for all working phases of the project, including a proposed EMMP, and to work closely with NParks to ensure that the relevant marine biodiversity stakeholders are engaged at the environmental study scoping stage.

The study approach, baseline and assessment are based on careful consideration of TAs' feedback. The assessment scope also takes basis from a thorough investigation of the project pressures and environmental receptors nearby that is presented in the sections to follow.

3.2 Environmental Scoping and Study Approach

An impact process is a description of how a specific receptor is affected by a specific type of impact: Pressure > Pathway > Receptor. All three elements are required for there to be an impact. For example, if there is no pathway from the source to the receptor, then no impact will eventuate; and if there is a source but no receptor, then there will also be no impact.

An environmental pressure is defined as a change in environmental condition (such as currents, wave, water quality, etc.) resulting from a development project. A sensitive receptor is a social, economic or ecological feature that may be affected by a pressure or a group of pressures. The subsections to follow discuss in detail the pressures of and relevant receptors to the development of interest.

The Project has potential to exert impact on sensitive environmental receptors within the vicinity of the site. Although the Project is anticipated to result in changes (pressures) on the physical, biological and socio-economic environments, it was identified in the screening stage that specific focus should be taken for the marine biodiversity as there were minimal impacts expected on other marine and terrestrial receptors. The spatial scope for analysis will be limited to the project construction area as the pressure is largely anticipated to be direct with minimal pressures with larger extents (e.g. sediment plumes).

3.2.1 Environmental Aspects

Based on the anticipated project activities, a logical and systematic approach is undertaken to identify and classify all of the important environmental issues and their interactions associated with the construction for further study and analysis to be addressed within the EIA and emphasize where and who in the project cycle has the means to prevent or mitigate the impacts. The aim is to account for all the important environmental impacts and interactions, and ensure that indirect and cumulative effects, which may be potentially significant, are not inadvertently omitted.

For the purpose of this EIA, the following environmental aspects related to the proposed project have been considered:

- Piling works for the jetty construction
- Direct impact due to the footprint of the proposed jetty piles

3.2.2 Study Area & Environmental Receptors

The spatial scope of the analysis of the potential impacts extends to cover the entire area in which impacts could potentially be realised. This ultimately ensures that all analyses are considered at the appropriate scale for all the relevant environmental receptors. Given the limited footprint of the jetty piles, the primary spatial scope of analysis for this study is the 330m of Marina South shoreline as illustrated in Figure 3.1. In addition, the actual location and number of jetties within the study area has not yet been confirmed as of this writing.

Within this study area, the environmental receptor of concern for this study is the subtidal marine habitats along the Marina South shoreline. The identification and description of the baseline conditions for this receptor are based on surveys carried out by DHI as well as desktop review of data from external sources.

Other receptors, which are situated outside the potential area of impact of the proposed construction, have been excluded from this assessment, including international borders, aquaculture, recreational facilities, water intakes, and outfalls, which are situated a

sufficient distance away from the construction site that they are not considered to be within the potential impact area.

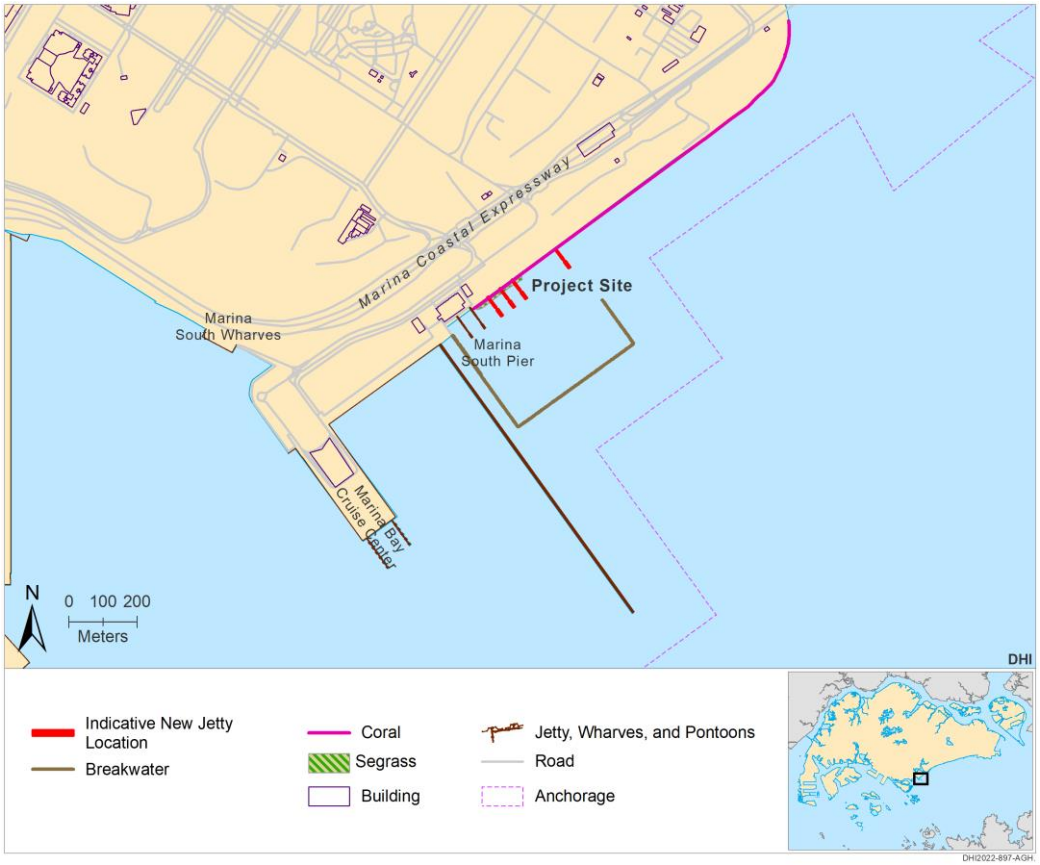


Figure 3.1 Environmental receptors located within the study area

This EIA covers the impact during construction and post-construction on the ecological receptors along the shoreline of the proposed construction site, but it does not cover any subsequent operational impacts associated with the jetty. Mitigation measures that can be implemented during design, construction and post construction stages will be elaborated accordingly. The baseline conditions will be established through a combination of physical surveys and desktop review of other data and information available to DHI. Given the near future of this construction project, the impacts will therefore be assessed based on the present-day development and receptor status.

With the above, the study covers:

1. Pre-construction coral survey to establish baseline of corals at development site, define baseline marine biodiversity
2. Characterise and classify impacts on marine habitat Impact Assessment matrix
3. Blue Group Engagement to obtain and incorporate feedback into study and outcomes
4. Proposed Mitigation and/or Monitoring and Management to minimise impacts

4 Blue Group Engagement

As part of stakeholder involvement in the EIA process, DHI has engaged representatives from various blue groups on behalf of the agencies. The representatives who participated in the preliminary and baseline surveys are listed in Table 4.1. The environmental baseline is elaborated in Section 5.

Table 4.1 Representatives from various blue groups involved in the surveys

No.	Name	Blue Group	Survey (Date)
1	Daisuke Taira	NUS Experimental Marine Ecology Lab	Preliminary survey (8th March 2022)
2	Ying Shu Min Lynette		
3	Huang Danwei	NUS Reef Ecology Lab	Baseline survey (15th March 2022)
4	Foo Sze Hui		
5	Sam Shu Qin	Our Singapore Reefs	
6	Kua Kay Yaw	Marine Conservation Group of Nature Society Singapore	

The findings and proposed mitigation measures were shared with the blue groups for feedback during an online session on 6th April 2022. The following table summarised the comments/clarifications from blue groups and the corresponding responses and remarks:

Comments / Clarifications	Blue Group	Response	Remarks
How will the vibration that the piling works will impact the nearby corals?	Peter Todd	The construction method has not yet been finalized so the impacts (if any) could not be accurately determined. Buffer zone for coral relocation can be considered to address the potential impact.	Construction method and jetty locations still not finalized
Change the term “reef area” to something like “seawall area”	Huang Danwei	DHI will update in the report	Texts in the report were updated accordingly
Were there corals near the existing jetty area?	Peter Todd	Surveys were not done very near the existing jetties for safety reasons. But based on the survey results, corals are assumed to be present, and Jani Tanzil mentioned in the chat box that there are corals near the existing jetty area	Coral receptor map indicates that corals are present until the existing jetty
Where will the locations of the proposed new jetties?	Stephen Beng	Showed the indicative locations in the map, however, it was highlighted that these are still not finalized and the construction could also be in stages	Construction method and jetty locations still not finalized
Will there be continued monitoring also of the survival/fate of the translocated seagrass and corals to recipient sites?	Jani Tanzil	The scale of the project/relocation exercise is small, thus post-transplantation monitoring is not recommended	N/A
Is there also continued monitoring of ecologically enhanced jetty structures to evaluate the success of new habitat creation?	Sam Shu Qin	The scale of the project/relocation exercise is small, thus post-transplantation monitoring is not recommended	N/A

The comments from the Blue Group members have been addressed during the meeting, and the EIA report has been updated to incorporate these comments. The major comment that was raised was related to the location of the jetties and potential vibration impact during piling works but there is no update for them in in this regard as the construction method of the proposed jetties has not yet been finalised as of this study. However, recommendations to optimise the location of the proposed jetties away from high coral cover area has already been considered.

Figure 4.1 (Top left) Group photo of MPA representatives, blue groups representatives, and DHI marine biologists; (Top right) Dive briefing before carrying out coral survey; (Middle left) Sam Shu Qin from Our Singapore Reefs doing LIT survey; (Middle Right) Huang Danwei from NUS Reef Ecology Lab recording the hard coral species encountered; (Bottom) Blue groups representatives and DHI biologists after coral survey

5 Environmental Baseline

The purpose of determining the environmental baseline conditions in the proposed development area is to provide a basis for the assessment of the scale of impacts, if any, originating from the project. An established environmental baseline also allows comparison once the works are completed to determine if there has been any change in conditions on site. During the baseline surveys, primary field sampling and secondary data research were carried out to properly establish baseline conditions of the project area.

For this EIA, a combination of qualitative and quantitative surveys along the 330m of rock revetment to the east of Marina South Pier along Marina South were carried out on 8 and 15 March 2022 respectively. This covered the direct impact footprint as well as adjacent areas could be potentially impacted. This surveys as well as other applicable desk-based assessment and literature reviews were used as the basis for the following assessment process as part of this impact assessment study.

5.1 Marine Ecology and Biodiversity

The coastline along the Marina South foreshore is protected by a rock revetment (~1.3 km), which has been in place for about 40 years. This modified marine habitat are the closest ecological receptor to the proposed development works.

The nearshore location of these habitats along Marina South foreshore suggests that they may be subjected to greater levels of background turbidity and sedimentation from wind/wave driven resuspension, ship wakes from the operations of Marina South Pier, as well as discharges and run-offs from a nearby drainages. The baseline ecological condition and characteristics of these marine habitats at Marina South described below are based on a combination of qualitative and quantitative surveys carried out on 8 and 15 March 2022 by DHI and members of Blue Groups.

Preliminary survey (rapid qualitative assessment) was done on 8th March 2022. The approximately 330 m coastline were divided into 3 areas, as C01, C02 and C03 (Figure 5.1). The rapid qualitative assessment was done by doing Visual Qualitative Spot Dive (detailed methodology description in Section A.2.1 of Appendix B).

Baseline survey (detailed quantitative assessment) was done on 15th March 2022, along the sea wall and the rocky berm of C02. The detailed quantitative assessment was done using Line Intercept Transect (LIT) method, which is widely used in Singapore and around the Indo-Pacific region to quantify the percentage cover of Scleractinian or reef-building corals as well as other major benthic lifeforms (detailed methodology description in Section A.2.2 of Appendix B).

In-situ water quality was carried out at C01 to C03 using EXO2 multi-parameter sonde from YSI on 15 March 2022. The water column was profiled using a calibrated EXO2 at 1 m depth intervals, from below the water surface to 1 m above the seabed. The measured parameters were temperature, salinity, pH, turbidity, and dissolved oxygen (DO).

Figure 5.1 Location of coral survey stations (Coordinates are provided in Appendix B)

5.1.1 Substrate and Topography

The sea wall (manmade rock bund) along the coastline of the study area extended to a depth of around -1 m CD and the part with relatively constant coral cover has a width of around 3.9 m. Beyond the sea wall, it was a relatively flat bottom with mixture of sand and silt substrate. A berm with consolidated (rocky) substrate was observed about 5 m away from the sea wall. The berm started at around 10-metre mark of transect C02 and extended eastwards until beyond the study area. The consolidated berm has a width of 13.8 m on average and extended to a depth of around -2.8m CD and as high as -1.6m CD.

The substrate distribution of the study area is illustrated in Figure 5.2.

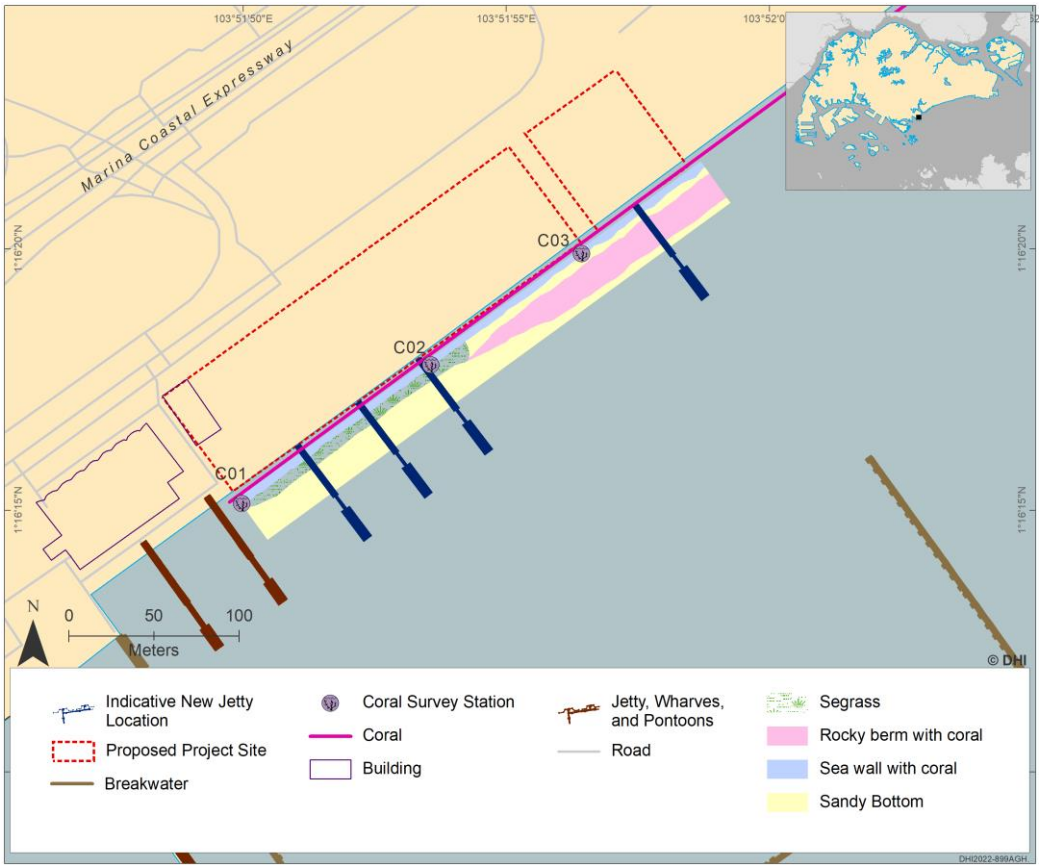


Figure 5.2 Habitat types at the study area (top view)

5.1.2 Marine Habitat

5.1.2.1 Preliminary Qualitative Survey

Preliminary survey provided the general information of the survey sites which became the basis for selecting the most representative area of the study site for quantitative survey to be carried out. Since the survey was carried out qualitatively, the coral cover provided in this section was just visual rough estimation.

During the preliminary survey, hard corals were observed growing along the sea wall. Coral cover was gradually increasing from west (C01) towards the east (C03) (Figure 5.2). Based on the visual estimation, C01, C02 and C03 were with hard coral cover of 20 %, 25 % and 30 % respectively. In contrast, hard coral cover on the rocky berm was higher and estimated to be about 40% up to 80% at some parts (Figure 5.2). This coral community extended along the length of the berm beyond the end of transect C03 and acts like a barrier to the sea wall. The hard coral genera encountered also increased eastwards (C01, C02, C03: 27, 28 and 33 genera respectively). Large corals were observed with a diameter of up to 3m. A total of 39 hard coral genera were recorded across the three sites with a few locally “Occasional” genera encountered.

Other benthic organisms such as sponges, ascidians and encrusting algae were also observed. Brown macroalgae *Sargassum* were all over the sea wall, indicating it was *Sargassum* blooms season during time of survey, which have been known to occur locally (Low and Chou, 2013)

Beyond the rock bund, along the sandy/silty substrate, a healthy seagrass meadow was observed. A total of three (3) species were encountered. the seagrass meadow was dominated by Spoon seagrass *Halophila ovalis,* and on some parts, mixed with Needle seagrass *Halodule uninervis.* A few stands of Tape seagrass *Enhalus acoroides* were also observed. The seagrass community extended up to about 5 m away from the base of sea wall and thrived at depth up to around -2.0 m CD. The seagrass meadow extended from C01 to before mid-way of C02 (total length ~ 130m). All the three seagrasses recorded are listed as “Vulnerable” on the Red List of threatened plants of Singapore (Davison, 2008).

The representative photos of the overview of the study area, the coral communities, and the seagrass communities were presented in Figure 5.3 to Figure 5.5. The hard coral genera checklist of the three sites were presented in Appendix B.

Figure 5.3 Overview of the sea wall and some representative photos during preliminary survey

Overview of the rocky berm

Large foliose *Pachyseris speciosa*

Branching *Acropora millepora*.

Massive *Porites lobata*

Submassive *Psammocora haimiana*

Plerogyra sinuosa

Encrusting *Coscinaraea* sp.

Figure 5.4 Overview of the rocky berm and some representative photos during preliminary survey

Spoon seagrass *Halophila ovalis* | Needle seagrass *Halodule uninervis* | Tape seagrass *Enhalus acoroides*

Figure 5.5 Representative photos of the seagrass communities in the study area during preliminary survey

5.1.2.2 Quantitative Baseline survey

Based on the preliminary observations, DHI carried out the detailed quantitative baseline surveys at C02, which is more representative of the study site. DHI carried out two LIT surveys, one along the sea wall, and one along the rocky berm. Both LIT surveys covered around 100 m of horizontal distance parallel to the rock revetment.

C02 - Sea wall

Hard coral was the most common living benthos on the sea wall of C02 with a mean cover of 38.56 % ± 6.34 (SE). The hard coral increased eastwards, 25.50% at the start and gradually increasing to 54.00% of the area surveyed. A total of 22 hard coral genera were encountered during the LIT survey and another 11 were found outside the transects. Of the 182 hard coral colonies recorded in the LIT survey, *Porites* was the most common genus both by occurrence (35 counts) and percentage cover (21.32 %). Foliose (44.32 %) and massive (34.26 %) were the more common growth forms encountered (Table 5.2). More than half of the coral colonies recorded were in the small to medium size classes, with a distribution of 34.62 % in Size 3 (10 to 25 cm) and 25.27 % in Size 4 (25 to 50 cm) (Table 5.2). There were ten (10) colonies of hard coral with size more than one (1) metre, which were from genera *Podabacia*, *Pachyseris*, *Porites*, *Turbinaria* and *Duncanopsammia*.

Algae also comprised a large part of living benthos on the sea wall of C02 (mean coverage: 29.57 % ± 5.60 (SE)). The algae comprised largely of macroalgae *Sargassum* (23.27 % ± 5.86 (SE)). The exceptionally high percentage of *Sargassum* was due to the seasonal *Sargassum* blooms that have been known to occur locally (Low and Chou, 2013). The other algae recorded were turf algae, coralline algae, macroalgae (*Bryopsis*, *Dictyota* and *Halymenia*), and algae assemblage. The only other living benthos observed on sea wall was sponge (2.18 % ± 4.68 (SE)).

The abiotic components on the sea wall comprised mostly of dead coral (12.81 % ± 4.09 (SE)), followed by rock (5.67 % ± 2.30 (SE)), sand (3.63 % ± 1.76 (SE)), rubble (3.44 % ± 2.45 (SE)), and silt (2.85 % ± 0.65 (SE)).

Selected photos illustrating the general environment at sea wall of C02 are presented in Figure 5.6.

Table 5.1 Mean percentage cover and standard error (± SE) (%) of the major benthic categories recorded during the LIT survey at the sea wall of C02

Benthic Category	Benthic Cover (%)	
	Mean	± SE
Hard Coral	38.56	6.34
Soft Coral	0.00	0.00
Sponge	2.18	2.09

Benthic Category	Benthic Cover (%)	
	Mean	± SE
Other Fauna	0.00	0.00
Algae	29.57	5.60
Dead Coral	12.81	4.09
Rubble	3.44	2.45
Rock	5.67	2.30
Silt	2.85	0.65
Sand	3.63	1.76
Other	1.29	0.67

Table 5.2 Lifeform distribution (%) and size class distribution (%) for all live hard corals recorded during the LIT survey at the sea wall of C02

Lifeform category	Distribution (%)
Massive	34.26
Foliose	44.32
Encrusting	15.98
Submassive	5.32
Mushroom	0.13

Size Class	Distribution (%)
Size 1 (<5cm)	4.95
Size 2 (5-10cm)	12.09
Size 3 (10-25cm)	34.62
Size 4 (25-50cm)	25.27
Size 5 (50-75cm)	11.54
Size 6 (75-100cm)	6.04
Size 7 (>100cm)	3.30
Size 8 (Stand >100cm)	2.20

Overview at sea wall and at the beginning of C02 – low coral cover and high *Sargassum* cover

Overview at sea wall and near the end of C02 – higher coral cover and lower *Sargassum* cover

The most common genus by percentage and by occurrence – *Porites* with massive lifeform

Size 7 *Turbinaria reniformis* with foliose lifeform

Encrusting *Pseudosiderastrea tayamai*

Mushroom coral *Herpolitha limax*

Figure 5.6 Representative photos at the sea wall of C02 during baseline survey

C02 – Rocky Berm

The mean hard coral cover recorded 46.18 % ± 6.29 (SE). There was more variation in this transect as the first 10 meters were on a seagrass meadow of Spoon seagrass (*Halophila ovalis*), which was growing on a soft silty substrate. Corals can only grow on hard substrates, which was why the coral cover in the first transect was 21.75 %. The hard coral cover on rest of the four transects on the rocky berm were quite uniform (47.70 to 55.95 %) with mean coral cover of 52.63 % ± 1.70 (SE). Of the 210 hard coral colonies recorded in the LIT survey, 26 hard coral genera were encountered during the LIT survey and another 14 were found outside the transect during a general observation of the study area. *Bernardpora* was the most common genus by occurrence (32 counts) while *Turbinaria* was the most common genus by percentage cover (19.85 %). Foliose growth forms were the most common (56.19 %), followed by massive (15.13 %), encrusting (14.85 %), and submassive (13.24 %). Branching *Acropora* and tabulate *Acropora* were also recorded with percentage cover of 0.32 % and 0.26 % respectively (Table 5.4). More than half of the coral colonies recorded were in the small to medium size classes, with a distribution of 32.86 % in Size 3 (10 to 25 cm) and 28.10 % in Size 4 (25 to 50 cm) (Table 5.4). There were six (6) colonies of hard coral with size more than one (1) metre, which were from genera *Turbinaria*, *Podabacia*, and *Montipora*.

A bed of locally “Vulnerable” Spoon seagrass *H. ovalis* was observed at the first half of transect 1 (cover 29.60 % of transect 1) but were not recorded in other transects. However, more seagrass were observed beyond the first two survey transects between the sea wall and the berm, likely because the area is covered in soft substrate and the berm creates calm hydrodynamic conditions that are suitable for seagrass growth. The overall mean coverage of the seagrass was 5.92 % ± 5.92 (SE).

Sponge, algae, and other living benthos (ascidian) were recorded in low percentage with mean of 2.86 % ± 0.79 (SE), 1.06 % ± 0.33 (SE), and 0.03 % ± 0.03 (SE) respectively.

The abiotic components recorded comprised mostly of silt (25.85 % ± 5.51 (SE)), followed by dead coral (5.67 % ± 2.30 (SE)), rock (3.63 % ± 1.76 (SE)), rubble (3.44 % ± 2.45 (SE)), and sand (0.79 % ± 0.62 (SE)).

Selected photos illustrating the general environment at rocky berm of C02 are presented in Figure 5.7.

Table 5.3 Mean percentage cover and standard error (± SE) (%) of the major benthic categories recorded during the LIT survey at the rocky berm of C02

Benthic Category	Benthic Cover (%)	
	Mean	± SE
Hard Coral	46.45	6.35
Soft Coral	0.00	0.00

Benthic Category	Benthic Cover (%)	
	Mean	± SE
Sponge	2.86	0.79
Other Fauna	5.95	5.91
Algae	1.06	0.33
Dead Coral	6.69	2.82
Rubble	4.34	1.88
Rock	4.91	1.30
Silt	25.85	5.51
Sand	0.79	0.62
Other	1.10	1.10

Table 5.4 Lifeform distribution (%) and size class distribution (%) for all live hard corals recorded during the LIT survey at the rocky berm of C02

Lifeform category	Distribution (%)
Massive	15.13
Foliose	56.19
Encrusting	14.85
Submassive	13.24
Branching *Acropora*	0.32
Tabulate *Acropora*	0.26

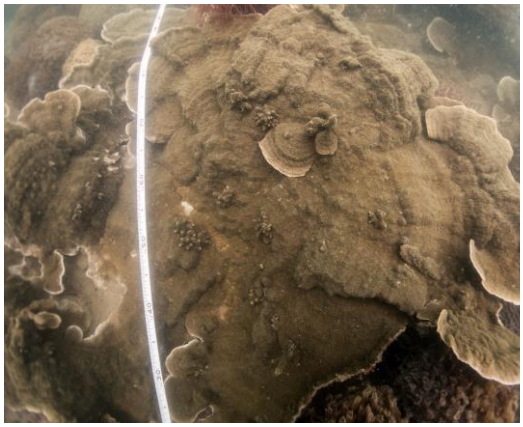
Size Class	Distribution (%)
Size 1 (<5cm)	6.67
Size 2 (5-10cm)	11.90
Size 3 (10-25cm)	32.86
Size 4 (25-50cm)	28.10
Size 5 (50-75cm)	11.43
Size 6 (75-100cm)	6.19
Size 7 (>100cm)	2.38
Size 8 (Stand >100cm)	0.48

Overview at rocky berm

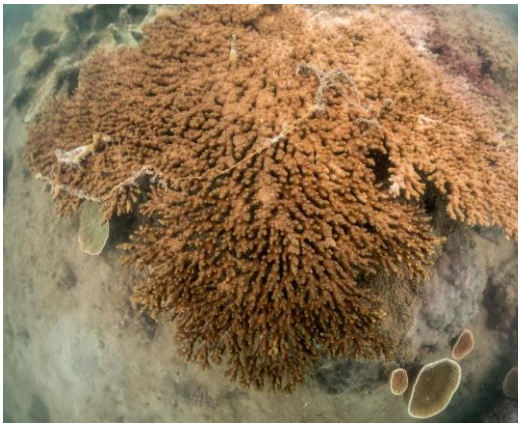
Spoon seagrass H. ovalis meadows at the start of transect

The most common genus by occurrence – *Bernardpora stutchburyi* encrusting onto debris

The most common genus by percentage – *Turbinaria reniformis*



Foliose *Montipora informis* with the most common growth form



Tabulate *Acropora* sp.

Figure 5.7 Representative photos of the coral communities at the rocky berm of C02

5.1.2.3 Hard Coral Diversity

A total of 44 hard coral genera were recorded from both the preliminary surveys and baseline surveys. Among them, 17 were categorised as “Occasional” genera based on DHI LIT survey database of over 250 unique sites (Table 5.6). The “Occasional” genera like *Lithophyllon* and *Plesiastrea* were encountered at relatively higher numbers.

A total of 83 hard coral species were recorded from both the preliminary and baseline surveys. Among them, based on Singapore Red Data Book Third edition (RDB3) (NParks, 2021), *Acropora digitifera* and *Acropora millepora* were locally “endangered” while *Dipsastraea pallida*, *Montipora grisea*, *Platygyra lamellina* and *Platygyra lamellina*) were locally “vulnerable” (Table 5.7 and Figure 5.8). Please refer to Appendix B for the complete species checklist.

Table 5.5 Summary of hard coral diversity at the study site

Hard Coral Diversity Indices	Overall Total
Number of Genera	44
- Number of Rare Genera	0
- Number of Occasional Genera	17
Number of Species	83
- Number of Endangered Species in RDB3	2
- Number of Vulnerable Species in RDB3	4

Hard Coral Diversity Indices	Overall Total
Estimated Area (seawall and rocky berm)	~ 0.40 ha
Estimated Coral Area	~ 0.15 ha
Estimated Total No. of Coral Colonies	~ 8,000
Estimated No. of Occasional Genera Colonies	~1,000

Table 5.6 Checklist of "Rare" and "Occasional" coral genera (DHI database) observed during the preliminary and baseline surveys

No.	Family	Genus	C01	C02	C03	DACOR*
01	Acroporidae	*Acropora*		√	√	Occasional
02	Coscinaraeidae	*Coscinaraea*		√	√	Occasional
03	Euphylliidae	*Fimbriaphyllia*	√		√	Occasional
04	Fungiidae	*Ctenactis*			√	Occasional
05	Fungiidae	*Herpolitha*		√		Occasional
06	Fungiidae	*Lithophyllon*	√	√	√	Occasional
07	Leptastreidae	*Leptastrea*		√	√	Occasional
08	Lobophylliidae	*Acanthastrea*	√	√		Occasional
09	Lobophylliidae	*Lobophyllia*		√		Occasional
10	Lobophylliidae	*Symphyllia*	√	√	√	Occasional
11	Merulinidae	*Oulophyllia*			√	Occasional
12	Oulastreidae	*Oulastrea*	√	√	√	Occasional
13	Plerogyridae	*Plerogyra*		√	√	Occasional
14	Plesiastreidae	*Plesiastrea*		√	√	Occasional
15	Pocilloporidae	*Pocillopora*	√	√	√	Occasional
16	Psammocoridae	*Psammocora*	√	√	√	Occasional
17	Rhizangiidae	*Pseudosiderastrea*	√	√	√	Occasional
Total			**8**	**14**	**14**	

**Relative generic abundance in Singapore based on DHI's LIT survey database of >250 unique sites using a semi-quantitative protocol (DACOR = Dominant, Abundant, Common, Occasional, and Rare; Maragos et al., 2004)*

Table 5.7 Checklist of coral species with conservation significance (NParks, 2021) observed during the preliminary and baseline surveys

No.	Family	Species	C01	C02	C03	RDB 3 Status*
01	Acroporidae	*Acropora digitifera*		√	√	Endangered
02	Acroporidae	*Acropora millepora*		√	√	Endangered
03	Acroporidae	*Montipora grisea*		√	√	Vulnerable
04	Merulinidae	*Dipsastraea pallida*		√		Vulnerable
05	Merulinidae	*Platygyra lamellina*	√	√	√	Vulnerable
06	Plerogyridae	*Plerogyra sinuosa*		√	√	Vulnerable
Total			**1**	**6**	**5**	

**RDB3 status is obtained from NParks' website (NParks,2021) which is intended to be published in the third edition of the Singapore Red Data Book in future*

Locally "Endangered" *Acropora digitifera*

Locally "Endangered" *Acropora millepora*

Locally "Vulnerable" *Montipora grisea*

Locally "Vulnerable" *Dipsastraea pallida**

Locally "Vulnerable" *Platygyra lamellina*

Locally "Vulnerable" *Plerogyra sinuosa*

Figure 5.8 Representative photos of the coral species with conservation significance (*Photo is obtained from internet as no usable photos from the survey are available – *Acropora millepora* (Veron *et al*., 2016); *Dipsastraea pallida* (BOS, 2022a); *Platygyra lamellina* (BOS, 2022b))

5.1.3 *In-situ* Water Quality Survey

Suitable ambient environmental conditions are necessary for the survival of the coral. For this purpose, *in-situ* water quality at C01 to C03 were collected to serve as baseline water quality data.

At present, there are no marine water quality standards for the preservation of coral health in Singapore; instead, the ASEAN Marine Water Quality Criteria (MWQC) for the protection of aquatic life is commonly used as a benchmark (ASEAN Secretariat, 2008). However, these criteria do not include guidelines or thresholds for many of the commonly recorded physicochemical parameters that are relevant for coral and seagrass health, e.g. turbidity, sedimentation. As such, relevant water quality guidelines from Thailand and Australia for the conservation of coral reefs which can be extrapolated for other marine habitats including seagrass have been tabulated below as reference values for this project (Table 5.8).

Table 5.8 Reference water quality criteria used for the monitoring and protection of coral health

Water Quality Parameter	Water Quality Standards / Guidelines		
	ASEAN	Thailand[1]	Australia[2]
Temperature	≤ 2˚C increase from max. ambient	No change from background	≤ 1˚C increase over max. ambient
Salinity	NA	≤ 10% from background	NA
pH	NA	7.0 – 8.5	8.0 – 8.4
Turbidity	NA	NA	6.0 NTU
Dissolved Oxygen (DO)	4.0 mg/L	≥ 6.0 mg/L	90% – 105% saturation (Approx. 7 – 9 mg/L @ 29˚C)

[1] *Class 2 – Coral conservation (Coastal Water Quality Standards of Thailand, 2004)*

[2] *Enclosed coastal waters (Water Quality Guidelines for the Great Barrier Reef Marine Park, 2010 & Queensland Water Quality Guidelines, 2009)*

The water quality parameters measured have been averaged and presented along with their standard deviations (SE) (Table 5.9). Note that median was provided for pH instead of mean as averaging of pH involved calculation of hydronium ion (Currie, L. A. and Svehla, G., 1994), which was deemed unnecessary due to the relatively constant pH reading in our study. The water quality parameters were all within the guidelines for the conservation of coral reef health.

Table 5.9 Summary of baseline water quality parameters recorded at study site on 15 March 2022

Site ID	Temperature (°C)		Salinity (ppt)		pH		Turbidity (NTU)		DO (mg/l)	
	Mean	± SE	Mean	± SE	Median	± SE	Mean	± SE	Mean	± SE
C01	29.04	0.00	31.11	0.00	8.15	N/A	0.23	0.00	6.51	0.00
C02	29.06	0.00	31.18	0.00	8.14	N/A	0.18	0.02	6.40	0.00
C03	28.97	0.01	31.19	0.00	8.15	N/A	0.32	0.02	6.42	0.00

5.1.4 Summary

The gradient of sea wall was approximately 1:3. The start of the slope was at a depth of +0.6 m CD) and the base of the sea wall was at a depth of -1.0 m CD) (Figure 5.9). The coral cover was observed to be more concentrated at the lower part of the slope. From the detailed quantitative baseline survey at C02, it is confirmed that the observation at the sea wall during preliminary survey the coral cover gradually increased from the west to the east of C02 (around 25 % to nearly 55 %). As such, along the sea wall, C01 area was estimated to have the lowest coral cover (~ 25 %) while C03 has the highest coral cover (~ 55 %) based on C02 results and combined with visual estimations during the preliminary survey.

Beyond the sea wall, it was a relatively flat bottom with mixture of sand and silt substrate. A seagrass meadow (area: ~ 650 m^2) was observed along the western transects closer to the existing jetties. The extent of the seagrass was approximately 130 to 150 m long from start of C01 to northeastwards along the shoreline and extended 5m seawards from the base of sea wall. The seagrass meadows were predominantly *Halophila ovalis,* and occasionally mixed with Needle seagrass *Halodule uninervis*. Three (3) stands of the Tape seagrass *Enhalus acoroides* were also observed.

A berm with consolidated (rocky) substrate with thriving coral community was observed about 5 m away from the sea wall. This coral community on the rocky berm acts like a barrier to the sea wall. The berm started at around 10-metre mark of transect C02 and extended eastwards until beyond the study area. The berm was observed to be narrow at the western tip and with a gradual increase in width up to 20 m at some parts towards the east. On average, the consolidated berm was 13.8 m wide. The mean coral cover on the rocky berm was 52 %.

No lower reef community was observed at the study area. Although suitable substrate is available for recruitment, the area is generally shallow. The water depth was only around -2.8 m CD at the deepest part of the rocky berm while lower reef communities are usually found at depth beyond -6m CD in Singapore.

In general, the hard coral communities at the study area were observed to be mature, given the presence of large coral colonies. This is unsurprising as the rock revetment was constructed more than 40 years ago, giving time for the recruitment and growth of marine organisms. There were several hard coral colonies with ≥ 1 m diameter. Large foliose coral with a diameter of up to 3 m was observed.

There was a total of 44 hard coral genera recorded from both the preliminary and baseline surveys. Among them, 17 were categorised as “Occasional” genera based on DHI LIT survey database of over 250 unique sites. The “Occasional” genera like *Lithophyllon* and *Plesiastrea* were encountered at relatively higher numbers. Although there was no rare genus recorded but based on RDB3 (NParks, 2021), there were two locally “endangered” species (*Acropora digitifera* and *Acropora millepora*) and four locally “vulnerable” species (*Dipsastraea pallida*, *Montipora grisea*, *Platygyra lamellina* and *Platygyra lamellina*) from the 83 hard coral species encountered.

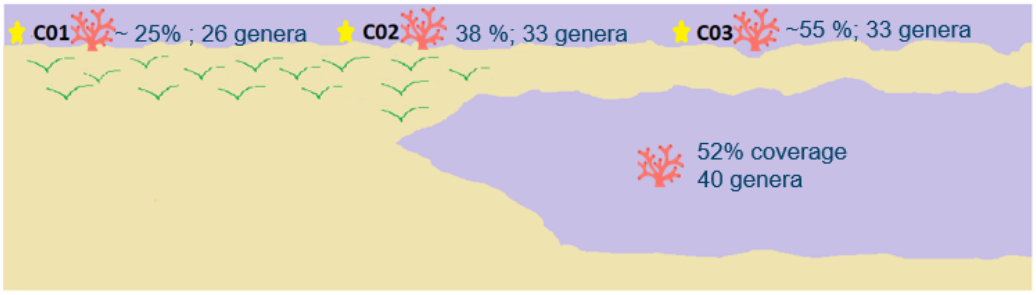


Figure 5.9 Spatial map of the various benthic communities observed along the shoreline of the study site

6 Impact Assessment

Potential impacts have been assessed based on analysed project-induced physio-chemical, biological, or socio-economic deviations from the established baseline (i.e. present day conditions) and the corresponding significance of this in comparison to environmental regulation (i.e. standards, guidelines, benchmarks, and tolerance limits) and sensitive receptors.

In this EIA report, focus is on the qualitative review of existing survey data, pre-construction baseline coral survey and other consultation data and associated impacts on the marine habitat receptors.

6.1 RIAM: Evaluation of Impact Significance

DHI has applied the well-recognised Rapid Impact Assessment Matrix (RIAM) methodology for assessing and summarising the overall significance of impacts related to the development. This methodology allows for a holistic, rapid and transparent presentation and summary of the overall project impacts, and ultimately aids in pinpointing which impacts are most significant. The use of RIAM determines how impacts are discussed and presented in the various impact assessment sections of the EIA report. A brief overview of RIAM methodology is given to aid the readers understanding of the reporting approach for each impact vector.

6.1.1 RIAM Methodology in Brief

With RIAM, the significance of an impact is determined by translating an environmental score (ES) to impact significance ('Slight,' 'Minor,' and 'Moderate,') via a predetermined list of impact levels (see Appendix A). The main thrust of the RIAM tool is therefore to assign an environment score to each relevant environmental component of a project. The formula for determining the ES is as follows:

Environmental Score (ES) = I*M*(P+R+C)
The formula variables are defined as:
(I) Importance – Assigns a level of importance in terms of the socio-political interests related to the receptor.

(M) Magnitude – Expresses the level of change in a physio-chemical parameter or the scale of loss/change to ecological and socio-economic receptors. Importantly, the value should reflect the magnitude of change at the particular receptor. In this way, the impact pathway is considered, i.e. whether there is a spatial and/or temporal overlap between the change and receptor.

(P) Permanence – Assigns a score based on the duration of an impact, i.e. the temporal scale of loss/change.

(R) Recoverability – The score expresses whether the receptor can recover from the impact.

(C) Cumulative Impact – A score is defined based on the cumulative potential of an impact.

The RIAM approach therefore couples the potential 'impact magnitude' at the sensitive receptor(s) in question with an assessment of the Importance, Permanence, Recoverability and Cumulative Impact in the Environmental Score formula.
The Importance (I) and Cumulative Impact (C) potential are more subjectively determined or based on expert opinion, whereas Recoverability (R) and Permanence (P) of the impact are related to the duration of a certain project activity or the possibility of a receptor to recover from or to reverse the impact.
For the purpose of this EIA, potential impact 'Magnitude' (M) is based on the relationship between the analysed physio-chemical, biological, or socio-economic deviation from the baseline (i.e. present day conditions in this case) and the environmental standards, benchmarks, guidelines, or tolerance limits established in the legal framework for this EIA. Table 6.1 provides definitions for the various potential 'Magnitude of Change' categories, while additional detail regarding the RIAM Methodology can be viewed in Appendix A.

Table 6.1 Definition of potential Impact Magnitude categories

Magnitude of Change	Category Definition
No Impact	Compliance with standard, guidelines or benchmarks does not change due to project or, in the relation to Port and Marine Ecology Tolerance Limits, magnitudes are below the level of model reliability or are significantly below recognised tolerance levels so that no change to the quality or functionality of a receptor will occur.
Slight Negative / Positive	'Slight' changes can be resolved by the numerical models, but are unlikely to be detectable in the field as typically 'Slight' negative changes are associated with changes that may cause limited stress (e.g. to marine ecosystems), while 'Slight' positive changes are associated with changes that may potentially reduce stress.
Minor Negative / Positive	A 'Minor' negative change is realised when there is change towards, but not approaching, non-compliance with established standards, guidelines or benchmarks. In relation to Port and Marine Ecology Tolerance Limits, minor negative magnitudes of change are identifiable by the predictive modelling tools (e.g. intense stress or mortality) which would also be identifiable in the field. Positive 'Minor' changes include the perceivable but spatially limited improvement in the baseline conditions at a certain environmental receptor.
Moderate Negative / Positive	'Moderate' negative change is evident when an analysed deviation approaches and is in danger of exceeding established standards, guidelines or benchmarks. Any non-compliance is locally relevant and would require alterations to project design and/or operational management in order to ensure general compliance. In relation to Port and Marine Ecology Tolerance Limits, 'Moderate' magnitudes of change are clearly and readily evident with predictive modelling tools (e.g. mortality, or excessive mean Total Suspended Solids concentrations). Positive 'Moderate' magnitudes of change include readily identifiable locally relevant improvements in the baseline conditions at a certain environmental receptor.
Major Negative / Positive	'Major' negative changes involve situations where established standards, guidelines, benchmark or tolerance limits are exceeded well beyond the project boundaries or when a complete loss of local habitat is evident. Depending on the significance of the change, impacts of this nature may be considered unacceptable and require substantial design-related mitigation measures to remediate the negative impacts on the physical, ecological or social environment. A 'Major' positive change would potentially greatly benefit the physical, ecological or social environment.

The 'Magnitude of Change' classification has been developed by DHI based on international standards in combination with DHI's experience in dredging and reclamation impact assessment in Southeast Asia, and has been applied to all of the major marine EIAs in Singapore over the past five years. As evident from Table 6.1, the definition categories

for potential 'Magnitude' (M) are based mainly upon compliance with applicable standards, guidelines, benchmark or tolerance limits. The remainder of RIAM variables of importance, permanence, recoverability, and cumulative impact are therefore more influential in determining the actual environmental score and impact significance (please note: the terminology used for the significance in the environmental score is the same as that for impact magnitude and should not be confused; e.g. slight, minor, moderate). As described below, this relationship is used to loosely structure each environmental assessment section in this EIA and provide an overall summary of impact significance at the conclusion of the EIA.

6.1.2 Application of RIAM in Environmental Assessment Sections

In general, each impact assessment section of the EIA aims to first present an analysis of compliance with established environmental standards, benchmarks, or tolerance limits. It then follows this with an explanation of the actual significance of the level of compliance in relation to the RIAM variables of importance, permanence, recoverability, and cumulative impact.

Compliance Analysis

Individual impact assessment sections are carefully structured to illustrate the key components involved in analysing environmental impacts, namely:

- Evaluation framework;
- Relevant sensitive receptors;
- Results and discussion of the impact and mitigation analysis; and
- A summary of pre and post mitigation (residual impact) impact significance.

The evaluation details the actual standards, guidelines, benchmarks or tolerance limits used to assess compliance, whereas the sections on relevant receptors outline key characteristics for impact analysis and the related sensitive features.
The analysis of potential impact magnitude takes place in the impact and mitigation analysis sub-sections. Here, for example, generated water quality modelling results allow for an analysis of the potential impact 'magnitude' in relation to water quality guidelines at a sensitive receptor. As a further example, modelled dumped generated suspended sediment plumes will indicate the potential impact magnitude on coral receptors in relation to established coral tolerance limits.

Statement of Impact Significance

The actual statement of impact significance is presented in the EIA in the following ways:

- A textual characterisation of the impact significance of the impact and mitigation analysis sub-sections and summary sections that are always confirmed and underpinned by the RIAM process and results tables.

- A tailored RIAM results table (pre- and post-mitigation) at the conclusion of each impact analysis section (Table 6.2).

- A cumulative RIAM results table (pre- and post-mitigation) of all impact analyses at the conclusion of the EIA report.

The following table illustrates a generic version of the RIAM Results table applied both at the conclusion of each impact assessment section and EIA report.

Table 6.2 Generic example of RIAM results table

Impact on Receptors	Predicted impacts without Mitigation							Mitigation Measures	Mitigated Impact Significance
	Impact Significance	ES	I	M	P	R	C		
Description of Receptor	e.g. Moderate negative	-	-	-	-	-	-	Reference to Section where mitigation measures are described	e.g. Minor

6.2 Impact Assessment

Although the footprints of the jetty piles are minimal, it is noted that their construction will lead to some loss of the biodiversity on the direct footprint within the 330m stretch of rocky shoreline along Marina South. The impact significance of the changes identified is summarised in a RIAM matrix in Table 6.3. For the most part, there will be minimal short-term and long-term negative residual impacts to any of the relevant environmental receptors identified and described in Section 3.2.2.

This takes into account the magnitude of change as described in the sections above, the importance of the ecological feature (i.e. its level of protection or ranking as a threatened species or habitat), the permanence of the impact, the ability of the feature to recover and the potential for cumulative impact. All impacts assessed for the marine habitat in this study are considered as ranging from 'Slight Negative' to 'Minor Negative'.

Table 6.3 Summary of identified negative impacts and assessment ranking with proposed mitigation measures

Receptor	Pressure	Predicted Impacts without Mitigation							Mitigation	Mitigated Impact Significance
		Impact Significance	ES	I	M	P	R	C		
Coral Habitat	Construction of jetties will directly and indirectly impact (e.g. shading) the sensitive coral and other benthic diversity	Minor Negative	-48	3	-2	3	3	2	Relocate the rare and occasional corals within the direct footprint of the jetty piles and shaded area by the jetty onto a potential recipient area away from the construction works (Described in Section 7)	Slight Negative
Seagrass Habitat	Construction of jetties will directly and indirectly impact (e.g. shading) the sensitive seagrass habitat	Minor Negative	-48	3	-2	3	3	2	Relocate the three Vulnerable seagrass species within the direct footprint of the jetty piles and shaded area by the jetty onto a potential recipient area away from the construction works (Described in Section 7)	Slight Negative
Marine Habitat / Water Quality	Construction of jetties may increase the concentrations of suspended sediments due to ship wakes	Slight Negative	-21	3	-1	2	2	3	Not necessary	Slight Negative

Receptor	Pressure	Predicted Impacts without Mitigation							Mitigation	Mitigated Impact Significance
		Impact Significance	ES	I	M	P	R	C		
	and propeller wash									

Table 6.4 Summary of identified positive impacts and assessment ranking with proposed mitigation measures

Receptor	Pressure	Predicted Impacts without Mitigation							Mitigation	Mitigated Impact Significance
		Impact Significance	ES	I	M	P	R	C		
Coral Habitat	Creation of potential new habitat (jetty columns	Minor Positive	48	3	+2	3	2	3	The jetty piles will create new potential suitable substrate for biodiversity recruitment, which can be enhanced or ecologically engineered to encourage colonisation by corals, and other fauna and flora.	Minor to Moderate Positive

7 Environmental Management Framework

7.1 Mitigation

7.1.1 Biodiversity Transplantation

Biodiversity transplantation will help to offset the predicted direct and indirect loss of marine biodiversity caused by the development, thereby reducing the overall level of impact. There can be net benefits from the conservation of marine species, particularly species of conservation significance. Habitat quality can also be improved at the recipient site. The recommendation for the proposed biodiversity transplantation works detailed in this plan should be implemented. A summary of these recommendations is provided below.

7.1.1.1 Pre-Construction Biodiversity Survey

Once the number and locations of the jetties are finalized, a pre-construction biodiversity survey should be carried out along the footprint of the piles and the area that will be potentially shaded by the new jetties. The survey will provide an assessment of the presence or absence of seagrass as well as “rare”, “occasional” and endangered coral species within the impact area.

7.1.1.2 Seagrass Habitat

Along the western half of the study site, three Vulnerable species of seagrass were recorded beyond the base of the seawall with an estimated area of about 650 m^2. The three species of seagrass observed were *Halophila ovalis*, *Halodule uninervis* and *Enhalus acoroides*. These three species are listed as Vulnerable in the Singapore Red Data Book and if the final location of the jetty piles will have a direct impact to the seagrass community, a small scale relocation exercise is recommended to remove these seagrass along the impact area and transplant to a nearby suitable recipient site away from the construction site.

7.1.1.3 Coral Habitat

Hard corals form the structure and framework of coral reefs and are home to a multitude of marine flora and fauna. The Baseline surveys carried out for this project found that the coral communities within the study area had a relatively high density and diversity of live hard corals (Section 5). The estimated coral reef habitat is estimated to be about 0.4 ha which is comprised of the rock revetment and a submerged rocky berm along the shoreline of Marina Coastal Drive. A total of 17 “occasional” genera were observed within the study area. In addition, two and four coral species are listed in the Singapore Red Data Book as Endangered and Vulnerable respectively. If these corals of conservation significance are observed to be within the final jetty piles footprint and the area that will be potentially shaded by the jetty, a targeted coral relocation exercise is recommended to remove all these corals along the impact area and transplant to a nearby suitable recipient site away from the construction site.

7.1.1.4 Habitat Enhancement

The completion of the proposed new jetties will lead to the creation of potential new suitable substrate for biodiversity recruitment. The base of the jetty piles can be enhanced or ecologically engineered to encourage colonization by corals and other flora and fauna. Post-construction monitoring of the biodiversity recruitment and development is also recommended to assess the success of the new habitat created.

7.2 Monitoring & Management

In line with the objectives established during the screening and scoping phase of the EIA process, the mitigation, monitoring, and management is focused to ensure that direct impacts on the marine habitat along the affected seawall are carefully controlled.

The key components of the environmental monitoring plan include:

- Water quality monitoring
- Coral habitat monitoring (If Necessary)

7.2.1 Water Quality Monitoring

Two water quality monitoring stations are recommended for monthly *in situ* testing within the project footprint and outside of project footprint as control, as and when possible, considering the sea state and work schedule. These are proposed in order to monitor long term trends in water quality conditions and allow comparison against ambient water quality limits (i.e. ASEAN MWQC). The water quality shall be done one time before the construction phase (baseline), monthly during the construction phase, and one time after the construction phase. The parameters for testing should match those considered during the EIA.

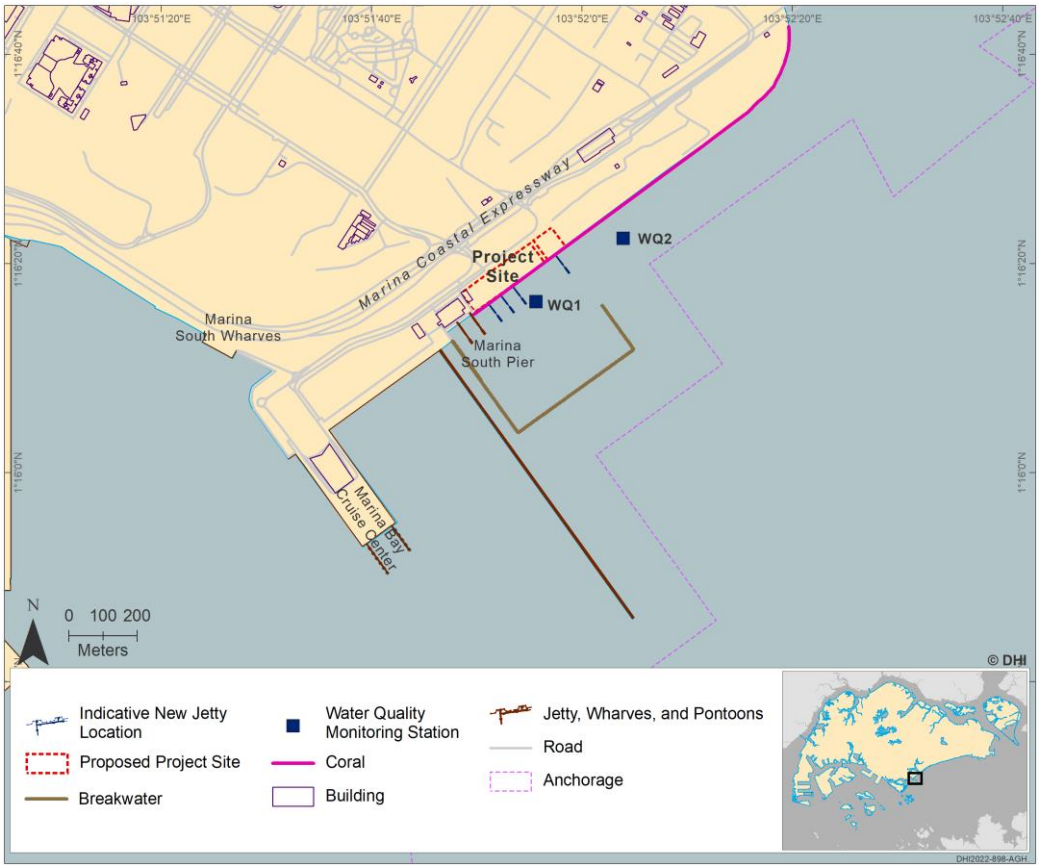


Figure 7.1 Proposed water quality monitoring stations (indicative only, subject to site conditions and relevant authorities' consent)

7.2.2 Coral and Seagrass Habitat Monitoring (If Necessary)

The proposed development works are not expected to have potential impacts to the corals and seagrass outside of the direct footprint and the adjacent coral community to the east of the project site along Marina Coastal Drive (shown in Figure 7.2). However, if the scope and method of construction (e.g. reclamation and capital dredging are required), a coral habitat monitoring is recommended.

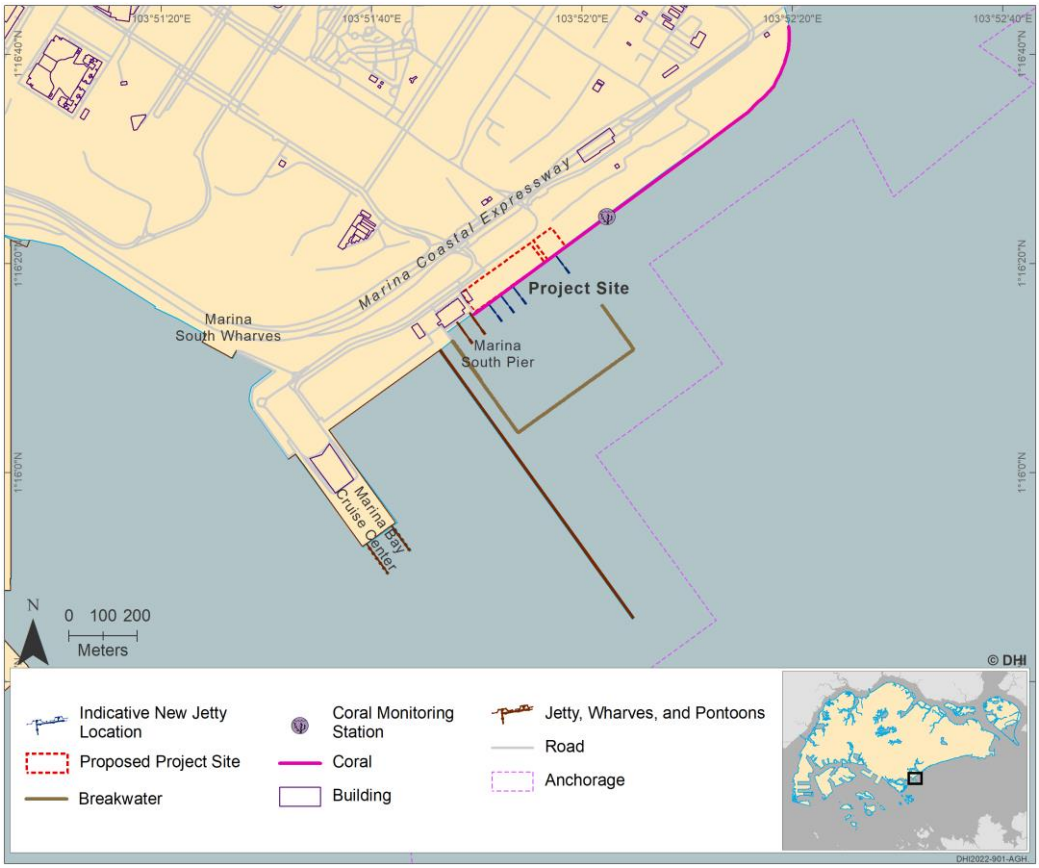


Figure 7.2 Proposed coral habitat monitoring location (indicative only, subject to site conditions and relevant authorities' consent)

8 Conclusions and Recommendations

The proposed integrated development along Marina Coastal Drive will have direct and indirect impacts to the coral and seagrass habitat within the project site. Impact levels ranging from Minor Negative to Minor Positive Impact are predicted prior to mitigation. After mitigation is implemented, impacts are reduced to Slight negative to Moderate Positive Impact. The key environmental changes and impacts are summarised below:

- **Coral Habitat**: The most significant impact is the loss of coral habitat along the direct footprint of the jetty piles. However, targeted relocation of rare and occasional species as well as the creation of potential new habitat by the newly constructed jetty piles will help offset the loss of habitat. There is also potential to ecologically engineer the base of the jetty piles to be more conducive to natural recruitment and recolonization of marine flora and fauna, such as corals.
- **Seagrass Habitat**: Direct loss to the seagrass habitat along the direct footprint of the jetty piles is also expected. Relocation of the affected seagrass area will help offset the loss of habitat.
- **Water Quality**: Construction of jetties may increase the concentrations of suspended sediments due to ship wakes and propeller wash. However, the intended launches that will utilise the proposed jetties will have shallow drafts with speed and movement limit. It is not anticipated to have significant impact to the corals and seagrass.

Recommended mitigation measures are detailed in Section 7, and include transplantation of corals and seagrass that are "rare" and "occasional" corals as well as listed in the Red

Data Book within the direct project footprint based on the outcome of the pre-construction surveys. Based on the receptors that were identified and their locations within the study site, the locations for the proposed jetty construction should be optimised along the areas where coral cover are low. The proposed jetty columns would be at the no-splash zone, if feasible, where regular maintenance is not required. The growth of the marine organisms along the jetty piles is beneficial to the structure protection.

In addition, implementation of an in-situ water quality monitoring during the construction and audit phases is also recommended. It is expected that the plume that will be generated during the piling works are small and temporary with rapid dispersion, leading to negligible impacts, thus silt screen is not necessary. Silt screen installation and demobilization will involve additional marine works (including barges for deployment/recovery of anchor blocks for the silt screens) which may potentially damage the corals or seagrass during the process. Furthermore, silt screen is efficient in areas where the water is calm. Given the project site will be experiencing string waves from the passing vessels, we foresee the efficiency may be low. In the event changes to the construction scope ensues, coral and seagrass habitat monitoring may be recommended. After appropriate mitigation measures are implemented, the project is considered to be feasible from an environmental perspective.

9 Reference

ASEAN Secretariat. 2008. ASEAN Marine Water Quality: Management Guidelines and Monitoring Manual. Australian Agency for International Development (Aus AID) under the ASEAN Cooperation Program, Regional Partnership Scheme with the ASEAN Working Group on Coastal and Marine Environment and the ASEAN Secretariat. 432 pp.

Currie, L. A. and Svehla, G.. "Nomenclature for the presentation of results of chemical analysis (IUPAC Recommendations 1994)" Pure and Applied Chemistry, vol. 66, no. 3, 1994, pp. 595-608. https://doi.org/10.1351/pac199466030595

Davison, G. W. H., Ng, P. K. L., & Ho, H. C. (2008). The Singapore Red Data Book: Threatened Plants and Animals of Singapore. 2nd Edition. Singapore: Nature Society (Singapore).

Low, J. and Chou, L.M., (2013). Sargassum in Singapore: What, Where and When? Taxonomy of Southeast Asian Seaweeds II; Phang & Lim (eds), 2013, 219-236

Maragos J.E., Potts D.C., Aeby G.S., Gulko D., Kenyon J.C., Siciliano D., VanRavenswaay D. (2004) 2000–2002 Rapid Ecological Assessments of corals (Anthozoa) on shallow reefs of the Northwestern Hawaiian Islands. Part 1: species and distribution. Pac Sci 58(2):211–230.

Ministry of Natural Resources and Environment, Thailand. (2004). [Online] Marine Water Quality Standards for Coastal Area. Available at: http://www.pcd.go.th/info_serv/en_reg_std_water02.html.

National Parks Board (2021). [Online] Stony Coral. Available at: https://www.nparks.gov.sg/biodiversity/wildlife-in-singapore/species-list/stony-coral [Accessed on 25-March-2022]

The Biodiversity of Singapore (BOS) (2022a). *Dipsastraea pallida* (Dana, 1846). Accessed 26 Mar 2022. https://singapore.biodiversity.online/species/A-Cnid-Anth-Scleractinia-000018

The Biodiversity of Singapore (BOS) (2022b). *Platygyra lamellina* (Ehrenberg, 1834) Accessed 26 Mar 2022. https://singapore.biodiversity.online/species/A-Cnid-Anth-Scleractinia-000043

Veron J.E.N., Stafford-Smith M.G., Turak E. and DeVantier L.M. (2016). Corals of the World. Accessed 26 Mar 2022. http://www.coralsoftheworld.org/species_factsheets/species_factsheet_summary/acropora-millepora/