

CITY REEFS

Marina at Keppel Bay

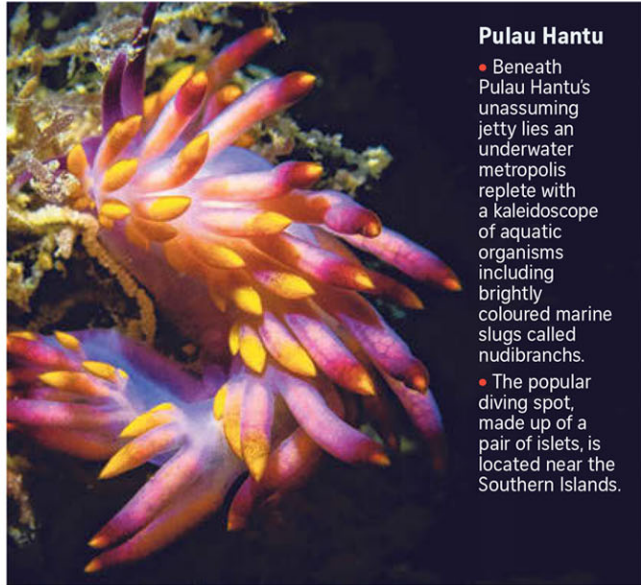
- Marina at Keppel Bay, where a shipyard used to be, has since evolved into a city reef teeming with more than 150 kinds of marine life including seahorses, critically endangered hawksbill turtles and clownfish.
- In taking over the area in 1992, Keppel redeveloped the marina to

allow currents to freely flow through, bringing in nutrients and coral larvae. Such design choices and strict controls on boat use provided fertile conditions for a rich variety of corals to grow beneath the floating pontoons.



Pulau Hantu

- Beneath Pulau Hantu's unassuming jetty lies an underwater metropolis replete with a kaleidoscope of aquatic organisms including brightly coloured marine slugs called nudibranchs.
- The popular diving spot, made up of a pair of islets, is located near the Southern Islands.



Reimagining Singapore's shores

In a short documentary series launched in March, final-year Yale-NUS student Nathaniel Soon explores how nature has thrived on the island's seawalls, reefs and canals, even amid development. He hopes planners will protect the Republic's rich coastal ecosystems. **The Straits Times** highlights six sites featured in the series.



NATURALISED CANALS

Berlayer Creek

Berlayer Creek, one of two remaining mangroves in the south of mainland Singapore, is made up of three types of habitats, including mangroves, rocky shore and mudflats.



Sungei Api Api

- Located in the north-east of Singapore, Sungei Api Api supports a mangrove ecosystem in Pasir Ris.
- In the 1990s, the river was deepened to 2m below the low-tide level to create a permanent channel of water, with more land allocated to it such that it could accommodate mangroves while meeting drainage needs. This was a change from the conventional method of concretising a river to make a canal.

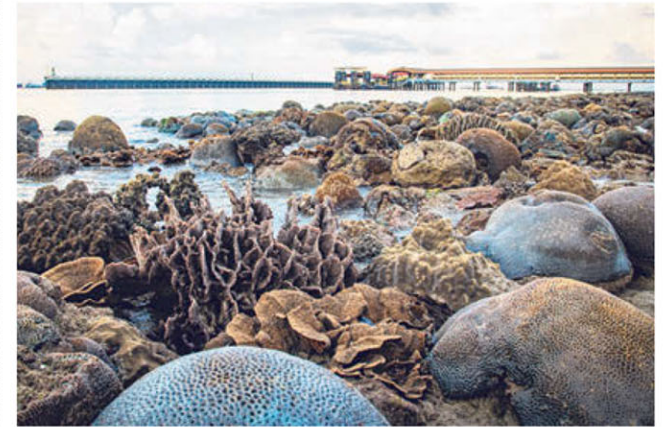


LIVING SEAWALLS

Tanah Merah Ferry Terminal

- A seawall at Tanah Merah Ferry Terminal is among seawalls and revetments – sloping structures to absorb the energy of incoming water – that hard corals have naturally settled on.

- Coral density and diversity have been known to exceed some natural reefs due to the presence of stable granite boulders.



East Coast Park

- Encrusted on an artificial embayment along East Coast Park is a colourful coral garden only visible during low tide.
- There is a greater sense of urgency to ensure development will not be detrimental to marine life with the

- possible future reclamation of coastal areas spanning Marina East, East Coast and Changi, Mr Soon said.
- A plan in 1991 envisions a reclaimed island there designated for leisure and housing development.



Readers can watch the documentary series at ourseasourlegacy.com/oceansreimagined

PHOTOS: COURTESY OF NATHANIEL SOON STRAITS TIMES GRAPHICS

Concerted push to create underwater paradise at Keppel Bay

Hidden below the busy pontoons of Marina at Keppel Bay is an underwater hub of life teeming with colourful corals, fishes and other marine creatures.

Occasionally, endangered spotted eagle rays and critically endangered hawksbill turtles have been spotted in the marina, Mr Alvin Lok, operational performance manager of Marina at Keppel Bay, said.

Keppel Bay is home to several luxury condominiums, including Reflections at Keppel Bay and upcoming development The Reef at King's Dock.

A dedicated team is behind the pristine conditions of the marina which opened in 2008. When heavy downpours last year washed soil from the coast into the marina, Mr Lok and his co-workers spent months sweeping layers of sediment off the corals.

"Because the reefs on the pontoons are so precious to us, we brought in oars to agitate the water such that it dislodges a bit of the sedimentation," said Mr Lok.

"The moment you have dirt settling on corals, it decreases the rate at which they can photosynthesise

and leads to their growth slowing down tremendously," he noted.

Each time there was torrential rain, the team would swing into action. "I think that helped to a certain extent, although everybody thought we were a bit crazy, they were telling us to wait for strong currents to wash (the sediment off the corals)," Mr Lok said.

Paradise in Keppel Bay did not occur overnight – in fact, it began about 30 years ago.

In 1992, visitors to the precinct would have been greeted by a murky shipyard that had been entrusted to Keppel Land, a subsidiary of infrastructure conglomerate Keppel Corporation, for redevelopment.

The secret to the marina's transformation lies in Keppel Land's philosophy for the precinct – that whatever was taken away from nature must be restored, said Mr Lok.

For example, the developer decided to spend \$30 million to build the cable-stayed Keppel Bay Bridge, instead of a cheaper solid structure akin to the Causeway.

The costlier choice allows currents to flow freely through the ma-



Corals at the Keppel Bay marina, which also teems with fishes and other marine creatures. A dedicated team is behind the pristine conditions of the marina which opened in 2008.
PHOTO: NATHANIEL SOON

rina basin, bringing in nutrients, plankton and marine larvae, while helping to remove sediment that would otherwise settle on marine organisms and smother them, Mr Lok said, noting that this is especially important for corals that rely

on currents for food.

The outcome has been visible from the clear waters in the marina as well as the higher density of hard corals – which take a longer time to grow – facing Sentosa, where current flow appears to be

stronger, he added.

Granite cladding on the seawalls in Keppel Bay was also selected to accelerate the recruitment of marine larvae on rough surfaces, despite the additional cost.

Floating sea-bins installed near

the pontoons of Marina at Keppel Bay filter out debris, such as plastics as small as 2mm in size, and surface scum brought in by the tides.

These design choices are complemented with management practices including a ban on fishing in the marina and pumping of raw sewage into the water.

Apart from providing optimal conditions for sea life, the management team also actively propagates coral reefs around Keppel Bay using stock from the marina.

All these initiatives have led to more than 150 marine life species identified just at the pontoons of the marina, said Mr Lok.

Studies by the National University of Singapore and National Parks Board have found that the abundance and diversity of fish and soft-bottom macrobenthos – organisms that live at the bottom of a water body – were higher within the marina compared with the adjacent open water areas.

Despite the additional effort and cost of developing the waterfront, Keppel Land sees the recreational, aesthetic and environmental benefits of incorporating biophilic design into its developments, said Mr Lok.

"It's not just about buying the buildings itself, it's also buying the surroundings," he added.

Ang Qing

Tiles that support marine life added to seawalls

They mimic natural habitat, and can double diversity compared with granite structures

Ang Qing

While seawalls are the traditional defence for Singapore's coasts against rising sea levels, scientists at the National University of Singapore (NUS) are re-engineering them to ensure they do not come at the cost of life underwater.

Despite the ability of the under-sea parts of some man-made defences to support coral communi-

ties, intertidal seawalls do not support biodiversity of the same richness as natural coastlines, said Associate Professor Peter Todd at NUS' Experimental Marine Ecology Lab.

More than 65 per cent of natural shorelines here have been transformed into hard coastal structures such as seawalls and rock slopes.

This is expected to increase in extent by the end of the century. In 2019, Prime Minister Lee Hsien

Loong announced that \$100 billion will be set aside for building Singapore's coastal defences.

To reduce the impact of existing seawalls on marine creatures, NUS scientists have developed an assortment of tiles that can be retrofitted onto seawalls to mimic natural habitat features.

The concrete tiles, from wedge-shaped "rock pools" to domes depending on the surface they are placed on, act as homes that are optimised to improve the variety of marine life.

Findings from their studies show that they can double the diversity of marine organisms on grey marine infrastructure, said Prof Todd.

He added: "The tiles can support between 20 and 25 species as compared to a traditional granite seawall, which has about 10 species. These organisms include algae, bivalves, quite a lot of marine snails and some crustaceans."

While these organisms may not appear to be charismatic, they are important food sources to sustain larger organisms such as fish in the shoreline ecosystem, he said.

Currently, 350 tiles are installed at Changi Bay and another 60 at Sentosa, according to Prof Todd.

After 12 years of experimentation with different designs and materials, the tiles have also been engineered to withstand Singapore's

tropical climate, which can see seawall temperatures soaring to 50 deg C, Prof Todd said.

Going forward, the team is refining the tiles to be more environmentally friendly, experimenting with various types of green concrete.

The tiles are designed to last 20 years, but this may vary depending on how exposed the shore is to waves, said Prof Todd.

Responding to queries on whether the National Parks Board (NParks) plans to install the tiles outside of Changi Bay Point, its group director for the National Biodiversity Centre, Mr Ryan Lee, said it is still too early to see the results of these microhabitats in enhancing marine biodiversity as they were installed only recently.

Regarding protection of coral communities along seawalls, he said that the board advises developers to take precautions to minimise damage to the corals in the event of coastal development.

"Where coral communities are large and established, NParks may require for the corals to be transplanted to other sites to prevent destruction," Mr Lee added.

While the current focus is to transform existing seawalls here into better homes for marine life, Prof Todd has hopes the team will ecologically engineer greener seawalls for Singapore in the future.

He said: "Building a hybrid seawall that softens hard coastal defences with green elements might be a bit more expensive and complicated than building a regular seawall, but this will come with biodiversity and cultural benefits."

The director of PUB's coastal protection department, Ms Hazel Khoo, said the national coastal protection agency will look beyond "hard" utilitarian engineering solutions by incorporating nature-based elements to enhance Singapore's coastal and marine environment.

Designing with nature is a key consideration as PUB conducts ongoing site-specific studies along the City-East Coast and north-west coast, where the proposed design of coastal protection solutions will target to maintain or even enhance biodiversity, she added.

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