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Investigation and Study of Epibenthic Corals near Hassyan Power Plant in Dubai

Wang Yina¹, Peng Cheng^{1*}, Xu ke¹, Zhang Qing¹

¹Tianjin Research Institute of Water Transport Engineering, Tianjin 300456, China

²CCCC Second Harbor Consultants Co.,Ltd, Wu han 430071,China

*Corresponding author's e-mail:chengpeng@tiwte.ac.cn

Abstract. Harbour and breakwaters of Hassyan power plant are located within Jebel Ali marine ecological reserve in Dubai, UAE. Project sea area has a good diversity and healthy environmental condition. Especially lots of live corals were found in this area. The distribution of epibenthic corals should be investigated in order to meet the requirement of environmental protection. The density, species and distribution were quantitatively estimated by the me thod of underwater video and remote sensing. The investigation showed that eighteen live coral species were recorded from six stations. Two of stations were moderately dense and the richest coral communities, while the other four were sparse communities. The highest cover rate was 37.89%. The investigation results provided basis datum for corals protection and translocation.

1.Introduction.

The Dubai Hasyan 4×600MW clean coal-fired power plant is located in the Saih Shuaib area on the coast of the Arabian Gulf (Persian Gulf) in Dubai, close to the border of Abu Dhabi. The project areas are primitive deserts that have not been industrially developed. This area belongs to the Jebel Ali Marine Ecological Reserve. The area has lagoons, mangroves, corals, wild antelopes, foxes, lizards, snakes and various birds, etc., with natural marine ecology and a complete biological chain system. The jetty breakwater project of the power plant needs to be carried out in the Jebel Ali sea area. In order to meet the environmental protection requirements of the project, it is necessary to investigate the distribution of benthic corals in the project area to provide a basis for the protection and transplantation of coral reefs.

For the investigation of coral reefs, many scholars at home and abroad have conducted related research. Chen Gang et al. ^[1,2] used Reef Check (coral reef health survey method) to investigate the coral coverage around Sanya and Weizhou Island respectively. Zhang Qiaomin et al.^[3] carried out the monitoring investigation and health assessment analysis of the benthic community by the dragging method, the cut-line spline method, the diving spline video and the digital photograph in the coral reef area of Luhuitou, Sanya, Hainan. Feng Xiaojie et al.^[4] used a combination of route surveys and consultation surveys to investigate the distribution, growth and development of corals and changes in biodiversity in the South China Sea. Niu Wentao et al.^[5] reviewed the evaluation methods of coral reef ecosystem health. In addition to field surveys, satellite remote sensing has also been widely used in the survey and monitoring of coral reef systems. Hochberg^[6] studied the influence of different sediments on the remote sensing monitoring of coral dishes through actual measurement spectrum analysis. Atkinson^[7] and others analyzed the reflectance of more than 10,000 corals, seaweeds, sand and other sediments on the spectrum worldwide. Holden et al.^[8] studied the spectral reflectance curves of coral

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and seaweed. Xu Bing^[9] studied related technologies such as remote sensing inversion of underwater topography of coral reefs in Guangdong Xuwen Coral Reef Reserve, analysis of sediment spectral characteristics, coral information extraction, and health status change detection. Hu Leiqiu and others^[10] used SPOT5 10m multispectral data to study the underwater identification ability of coral reefs in Nansha, my country. The above survey research methods provide effective research tools for coral surveys in this area.

2. Overview of the study area

The sea area of the project is located in the southeast of the Persian Gulf. In the northeast of the project, there is a newly built Waterfront artificial island. According to the measured data from the Jebel Ali tide station, the average annual water temperature of the sea area is 30° C, the lowest water temperature is 19.1° C, which occurs in January, and the highest water temperature is 35.2° C, which occurs in July. The salinity of sea water is between 39-42 PUS. The tide pattern of the project area is irregular half-diurnal tide, the tide is mainly reciprocating, the rising tide is southwest, and the ebb tide is northeast. The tidal current velocity of the engineering sea area is $0.01 \sim 0.06 \text{m/s}^{[11]}$. The strong wind direction is W~NNW, and the wind speed exceeds 15 m/s only 0.02% of the time throughout the year, and the wind speed is less than 3m/s 37.77% of the time. The waves are dominated by wind and waves, the direction of normal waves is WNW~NNW, and the direction of strong waves is NW. The wave dynamic conditions are not strong, the effective wave height is less than 0.5 m 72.72% of the time throughout the year, only 0.05% of the time the effective wave height will exceed 3m, and 90% of the wave period is less than $8\text{s}^{[12]}$.

3. Research methods

3.1. On-site investigation

A total of 26 survey stations have been set up in the coral reef survey area, namely M1-M26. The specific locations are shown in Figure 1. The survey adopted the cut-line spline survey method, and the cross-sections were sampled. The cross-sectional length was 30m wide and 2m wide, and the cross-sectional area was $0.25m^2$. It was taken every 5m along the 30m length, as shown in Figure 2. The underwater digital video cameras are used to record the transect shooting, and the indoor statistical analysis is carried out based on the image interpretation data and the identification data of coral reefs.

3.2 Satellite data sources

This coral reef survey uses remote sensing data from four different satellites, and the coverage areas of different satellites are shown in Figure 3. The remote sensing data of a large area comes from Landsat-8 and SPOT-7 satellites. The data collection time is distributed on July 26, 2016 and May 20, 2015. The SPOT-7 satellite was launched in 2014 with multi-spectral resolution. The rate is 6.0m. The remote sensing data of the target area mainly comes from the remote sensing image of the Pléiades satellite on April 22, 2016. Its visible light frequency band is the same as SPOT-7, but the spatial resolution is higher, which can reach 2.0m. The nearshore area uses WorldView-3 data on April 16, 2016, with a spatial resolution of 1.24m.



Figure 1. Distribution map of coral reef survey stationsFigure 2. Photo section at M23 station

3.3 Data processing

The amount of remote sensing image data is large, and necessary pre-processing is required before use, including radiometric correction, geometric correction, water and land separation, and image enhancement. Radiation correction is mainly to correct the distortion caused by atmospheric radiation, using Mausel.P.D^[13] improved DOS method (Dark-Object-Substraction) into the atmosphere correction.Geometric correction is achieved by selecting control points of the same name on the actual topographic map and satellite remote sensing map. The threshold method is used to separate water and land. The image inversion uses the object-oriented data inversion method proposed by Burnett^[14] and Purkis^[15,16]. This method not only uses the pixel information of the image, but also comprehensively considers the image's spectral characteristics, shape characteristics, organization structure and correlation characteristics. The inversion result was compared and verified with the data of 26 measured stations. The result showed that the accuracy of the obtained inversion image reached 92%, which could meet the needs of coral survey.



Figure 3 The coverage area of remote sensing satellites used in the survey

4. Results and discussion

4.1 Coral distribution and species

Table 1. Coral species and distribution									
Station	Water depth (m)	Water	Live coral	Dead coral	Station	Water depth (m)	Water depth (°C)	Live coral	Dead coral
		depth	coverage	coverage				coverage	coverage
		(°C)	(%)	(%)				(%)	(%)
M1	3.4	33.9	0	0	M14	8.2	34.2	3	0

M2	4.3	34.1	3	2	M15	7.7	34.2	0	0
M3	5.2	34.2	0	0	M16	6.9	34.4	0	0
M4	6	34.4	0	0	M17	2.6	34.1	0	0
M5	7.6	34.4	0	0	M18	3.2	34.2	5	0
M6	8	34.5	0	0	M19	7.4	34.5	0	0
M7	8	33.9	0	4	M20	8.3	34.1	0	0
M8	3	34.4	0	0	M21	4.6	34.3	0	0
M9	3.5	34.6	0	0	M22	4.2	34.5	0	0
M10	3	34.4	0	0	M23	4.5	34.5	37.9	12.1
M11	5.7	34	0	0	M24	4.5	34.5	4	1.2
M12	6.6	34.1	0	0	M25	3.7	34.4	17.5	5
M13	7.7	34.1	0	0	M26	6.4	34.5	0	0

Of the 26 stations surveyed in this survey, 6 stations have corals. Table 1 shows the water depth, temperature and coral coverage of each station. Among them, the stations with a large number of corals are M23 and M25, with live coral coverage of 37.9% and 17.5%, respectively, which are dense coral areas. M2, M14, M18 and M24 are sparse coral areas. From the perspective of distribution water depth, corals are mainly distributed in shallow water areas less than 4.5m. The selection of coral transplantation in the later stage needs to consider the influence of water depth in the transplantation area. In addition, more dead corals were found at stations M2, M7, and M23~25. Especially in M2, M23, and M25, thicker deposits were found, as shown in Figure 4. There are two main reasons for the deposition of these overburdens. One is the loss of sand during the construction of the Waterfront artificial island in 2007-2009, and the other is the weakening of tidal currents in the coral area after the completion of the artificial island, which causes further sedimentation of sediment. It can be seen that the sediment has an adverse effect on the ecology of the coral reef, so corresponding measures should be taken during the construction of this project to avoid the loss of filling mud and sand.

18 species of corals were found at the above 6 stations, as shown in Table 2. Among them, the most distributed are the turbinaria peltata, the cyphastrea microphthalma, the favia pallida, the platygyra daedalea, the porites lobata and the porites lutea, as shown in Figure 5 and Figure 6. The most widely distributed are thorn star corals and orange scallop corals, which exist in all survey stations.



Coscinarea monile				F	Р	Р
Pseudosiderastrea tayami				F		
Siderastrea savignyana			Р			
Turbinaria peltata		С				
Turbinaria reniformis				Р		
Cyphastrea microphthalma				F		С
Cyphastrea serailia	F	F	Р	F	Р	F
Favia favus						Р
Favia pallida	F	F		С		С
Favia rotumana						
Favites pentagona				Р		
Platygyra daedalea				С		С
Platygyra lamellina				Р		F
Acanthastrea echinata		Р				
Porites harrisoni						F
Porites lobata				С		С
Porites lutea	F	F	F	С	F	С
Number of species	3	5	3	10	3	11

Note: P: Existence; F: Visible (2-10 strains); C: Normal (11-100 strains); A: Abundant (101-1000 strains).

4.2 Remote sensing data results

Remote sensing images are based on different reflectivities and can also be used to distinguish seafloor sediments in order to facilitate research, the project area is divided into 8 areas.

- 1) Nearshore Sandy Sheets: From the broken zone to the area with a water depth of -2m, there are very few corals.
- 2) Sparse Coral: Coral coverage rate is less than 25%, and its average is about 10%.
- 3) Dense Coral: Coral coverage is 30%~70%, mainly coastal corals.
- 4) Coral Rubble and Hardground: mainly loose-cemented coral debris and rocky basement, with very few corals.
- 5) Offshore Sandy Sheets: sandy bottom with water depth deeper than 5m.
- 6) Muds with Microbial Mats: It is mainly located in the deep water area on the back wave side of artificial islands or breakwaters.
- 7) Sparse seagrass: covered with seagrass, the density is very sparse.
- 8) Dense Seagrass: covered with seaweed, with a density greater than 100 plants/cm².

The processed satellite remote sensing image is shown in Figure 7. It can be seen from the figure that the artificial island is surrounded by a circle of silt and sand bed intersecting the seabed (as shown in Figure 7A). The dense seagrass growth is mainly located on the west side of the artificial island approach dike (as shown in Figure 7C), with an area of about 800 m². The main reason for the massive growth of seagrass here is that the construction of approach dikes blocked the coastal sand transport from southwest to northeast, causing silt and fine-grained sediment at the roots of the dikes to form a soft foundation environment for seagrass growth. Sparse seagrass is widely distributed in the survey area. Unlike dense seagrass regions, sparse seagrass regions are more fragile and change with seasons. Within 1km from the shoreline on the west side of the artificial island is the area with the richest benthic biodiversity, where a biological zone is formed (as shown in Figure 7E). Most corals grow in this area, covering an area about 2 km². In the wave breaking zone several hundred meters away from the coastline, there is no significant benthic biota. Beyond the breaking zone, there is a hard-bottomed

seabed with a width of about 500m parallel to the coastline (as shown in Figure 7E). The main reason for the development of this seabed is that the high temperature and high salt in the Persian Gulf will cause calcium carbonate to crystallize and loosen. The sand cemented up to form a hard bottom seabed. The hard bottom seabed is a necessary condition for the growth and development of corals, so the breakwaters and revetment ripraps around the artificial islands can be used as receiving places for coral transplantation.



Figure 6. Dayuanpan coral at station M14Figure 7. Satellite remote sensing image

5. Main conclusions

In this paper, underwater exploration, satellite remote sensing measurement and other survey methods are used to quantitatively evaluate the density, species and distribution of corals in the project area of Dubai Hasyan Power Plant, and the following research results are obtained.

- 1) There are a total of 18 coral types in the project area, which are distributed in 6 surveyed stations, including 2 dense stations and 4 sparse stations. The maximum coral coverage density is 37.89% and the coverage area is 2km².
- 2) The sediment produced by the construction of the artificial island on the northeast side of the project area has an adverse impact on the ecology of the coral reef. Therefore, corresponding measures should be taken during the construction of the project to avoid the loss of filling mud and sand.
- 3) The hard bottom seabed is a necessary condition for the growth and development of corals. The breakwaters and revetment ripraps around the artificial islands can be used as receiving places for coral transplantation.

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