

THE OCEANWAY CORPORATION LTD

FINAL MONITORING  
REPORT,  
TUNG PING CHAU MARINE  
PARK

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The Hong Kong SAR Government

THE IMPROVEMENT WORKS TO  
THE TUNG PING CHAU PIER



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This report has been authorized by:



Paul Hodgson  
The Oceanway Corporation

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## EXECUTIVE SUMMARY

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- The Hong Kong Government Civil Engineering and Development Department has been given the task of up-grading the only public pier facilities at Tung Ping Chau. In order to protect the unique coral communities that grow in the marine area around the island, the waters around Tung Ping Chau was designated a Marine Park in 2001. The Tung Ping Chau Pier is located inside the Marine Park. A very comprehensive EM&A procedure was therefore established for the works.
- In order to facilitate the works, 41 colonies of coral were translocated from inside the works area. To allow impact monitoring to be carried out 15 colonies were selected around the work area (impact colonies) and 15 colonies were selected in nearby coral areas to act as a control (control colonies).
- A total of 17 impact monitoring surveys were carried out during the works period. There were no measurable impacts in the surrounding coral areas recorded in these surveys.
- In early August 2006 Typhoon Prapiroon affected this area and was responsible for the lost of seven of the control colonies and one impact colony. The survey regime was re-established in the next impact survey (Impact Survey 8) with the dislodged colonies being substituted by other carefully selected colonies under the same criteria.
- The final impact survey was carried out on 11<sup>th</sup> of March 2007.
- The CoralWatch survey detected the usual seasonal changes in the state of the coral during the survey period. The table below summarizes the results:

	Cumulative Average		
	Baseline	Final	Difference(%)
Impact	4.57	3.95	-13.57
Control	4.47	4.15	-7.16
Translocate	4.03	3.98	-1.24

Note that all areas have a decrease in the CA values between the Baseline and this Final Survey. The reason for the sudden drop in the coral health of the area is unknown. The previous impact survey (Survey Seventeen) showed a CA value above the Baseline values. It is likely caused by a combination of environmental factors. The large change for the Impact Stations may be the increase in boat traffic now on both sides of the pier affecting the water quality.

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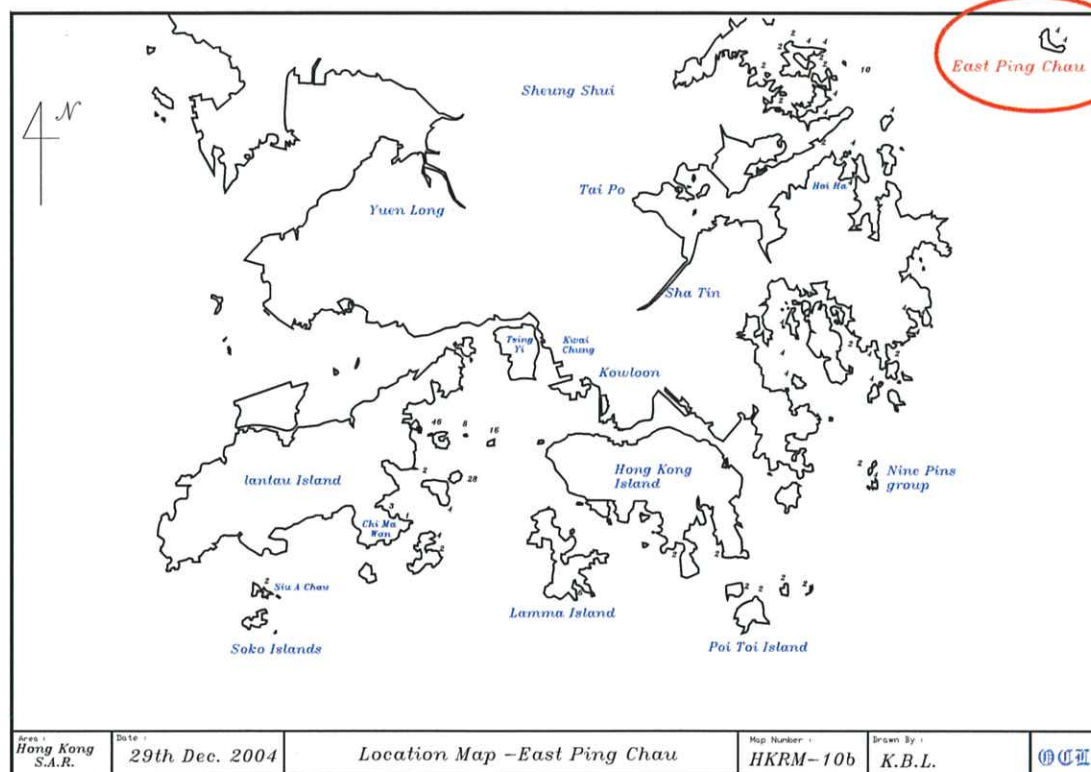
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## INTRODUCTION

The coral communities of Hong Kong are known as incipient reefs and are not typical of other high-latitude, non-reefal locations such as eastern and western Australia. Incipient reef coral areas have no calcium carbonate framework as a foundation for the corals, instead corals attach directly onto boulders and bedrock, forming simple pseudo fringing coral communities. Local coral communities are dominated by faviid species with massive, encrusting and foliaceous growth forms and over 84 species from 28 genera having been recorded. These corals tolerate wide annual fluctuations in water temperature (12-30°C) and salinity (20-35‰) (Cope 1982) and periodic typhoons.

On the 16<sup>th</sup> of November 2001, the waters around the small remote island of Tung Ping Chau was designated a marine park. This island is situated in the most north-eastern part of the Hong Kong SAR being only 3 kilometres from the Chinese Mainland and 11 kilometres from the rest of Hong Kong. The island is unique geomorphologically and the island, its shores and the surrounding marine area had been recognised as an area worthy of protection for at least four decades prior to the marine park designation (Morton 1996). A map showing the location of the island is in Figure 1.



**Figure 1. The location of Tung Ping Chau Island.**

Scleractinian stony corals exist in areas around the island, with some of the best examples of the local Hong Kong communities on the north side of the island. Table 1. shows some of the coral parameters of these areas. From this data it is possible to determine the importance of the Tung Ping Chau coral areas as compared to all other known coral areas in Hong Kong. The Replenishment Index and diversity of the corals in this area are second to none with respect to any other locally known coral areas. The size of the Tung Ping Chau coral area also makes it a very important centre of biodiversity for Hong Kong corals.

**Table 1. Characteristics of the coral area around Tung Ping Chau, Hong Kong (Oceanway 2002a).**

Parameter	Value	Highest recorded value for HK Corals (Location)
Community Type	Grade A	Grade A
Live coral cover (Max. recorded).	61.10 %	76.7% (Crescent Island)
Dead coral cover (Max recorded)	3.3%	68.5% (Tai Pai)
Rarity Index	1.72	4.19 (Long Ke Wan)
Replenishment Index	4.6	4.6 (Tung Ping Chau)
Diversity	45	45 (Tung Ping Chau)

The island has one pier that allows boat access. This pier is in dire need of up-grading and this work must be carried out with due consideration and protection to the surrounding marine environment. The up-grade works necessary to cater for the growing number of visitors to the island and for safety reasons.

In October 2005, a survey determined that there were 41 coral colonies that would be affected by the works associated with the installation of two caisson piles required for the pier works.

In January 2006, all of the colonies deemed to be impacted by the works were successfully relocated to Core Area A (Appendix A). A total of 45 colonies were tagged as part of a monitoring regime set up to monitor the necessary pier construction work:

- a. The status of the relocated coral colonies (15 relocated colonies).
- b. The status of the corals immediately around the works area (15 impact colonies).
- c. The status of the nearby coral area (15 control colonies).

In January 2006 corals were translocated and baseline survey was taken to allow assessing the initial status of the coral colonies situated in the areas of concern.

The first Impact Survey was carried out in April 2006 to monitor the conditions of tagged corals around the pier area and to determine any impact during the construction period on the coral colonies. A total of 17 Impact Surveys were conducted regularly to assess the condition of the corals and to detect any stress or damage.

On the 2<sup>nd</sup> and 3<sup>rd</sup> of August 2006 a typhoon struck the area. A spot check carried out on the 8<sup>th</sup> of August 2006 revealed that eight of the tagged coral colonies were lost. The survey was re-established on the 3<sup>rd</sup> of September 2006 (Impact Survey 8).

This final monitoring survey was carried out in April 2007. The final status of the tagged corals were determined with the overall changes documented.

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## MONITORING METHODOLOGY

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Monitoring methodologies, both Impact Survey and ControlWatch Survey were conducted to monitor for any impact that the pier renovation may have on the surrounding coral colonies. Both of these survey methodologies compliment each other. One, the impact survey, detects the environmental situation. CoralWatch indicates the stress levels of individual coral colonies. Each survey method is explained separately below.

### **Impact Survey**

The procedures for the setting up and carrying out this survey are detailed in the EM&A for this project. Basically three groups of corals were tagged in different areas to fulfil the requirements of impact colonies, control colonies and translocation colonies. Fifteen impact and translocation colonies were selected for each area. The EM&A only required 5 colonies to be used for Control purposes and these colonies should be situated more than 100m from the pier. It was considered prudent to tag an equal number of colonies for both Impact and Control areas, with the control consisting of 8 colonies on one side of the pier and 7 on the other (Appendix B). This would cancel out the effect of water currents in the bay.

### *Coral Colony Tagging*

Trained divers swam around the pier and located 15 suitable colonies for tagging. Colonies of similar size, similar species to the colonies at the pier and those known to clearly indicate stresses were selected. Colonies selected also had a reasonable horizontal profile in order to show sediment deposition. The process was repeated on both sides of the pier at a distance greater than 100m. Seven colonies were tagged on the northern side and 8 colonies on the southern side of the pier. Appendix B shows the locations of all colonies tagged, including the relocated colonies in Core Area A. Steel rebars were installed nearby the recorded coral colonies, with tags attached to individually identify the corals recorded. Tags consisted of Perspex tags each with a unique identification number. These were attached to the rebars with a cable tie.

### *Tagged Coral Colony Survey*

Details of each tagged colony were recorded. Typically the following data and parameters were noted.

- a. Species.
- b. Size (cm<sup>2</sup>)
- c. Growth form
- d. Partial Mortality
- e. Sediment (thickness, type and colour).
- f. The general health of the coral. This data will be supplemented with the CoralWatch data.

Divers knowledgeable with Hong Kong corals and trained to carry out such work collected this data. Each tagged colony was photographed and the location mapped.

## CoralWatch Survey

In order to establish the health status of the tagged coral colonies in a repeatable way, a CoralWatch Survey was carried out on each colony. This included the relocated corals before and after the event (several hours apart). The data collected would be used to determine the status of the whole group of colonies, i.e. all Control Colonies, and all Impact Colonies as well as the individual colonies if limits were exceeded.

This survey technique provides a simple method of monitoring the condition of hard corals by the use of simple graded colour charts underwater. The University of Queensland, Australia, was responsible for developing this survey methodology. The colour charts are a standard and are based upon the actual colours of bleached and healthy corals. Each colour square corresponds to a concentration of symbionts (zooxanthellae) contained in the coral tissue and this is directly related to the coral's condition. The process is simple, accurate and non-invasive. It is expected that this survey will be repeated each time an Impact Survey is required in an area. This way a quick and reliable result comparison with the baseline results and the control area results may be achieved. This survey methodology allows individual coral colony stress to be identified rapidly.

### *Field Procedure*

All recorded corals were surveyed using the Standard Chinese CoralWatch Chart. A total of 15 tagged corals were examined *in situ* in each area. The lightest and darkest colour match was determined. Data was recorded on prepared underwater sheets for later analysis. Care was taken to avoid the colour of the tips of the corals since there can be a delay in the colouration due to the required up-take time for zooxanthellae to enter the coral tissue.

### *Data Analysis*

The data were arranged as groups for each site (Impact, Control and Transplant). The numerical difference and the colour score were calculated for each colony and the average for the entire group was determined.

### *Data Results*

The results are presented graphically so that changes in the results can be clearly observed. Graphs will be compared over time with the actual colour data being compared cumulatively in a single graph for each area. These graphs show the area as a group of bars along a numerical axis indicating the level of bleaching. Typically the numbers from 0~5 are used. A value of 0 means no blanching; values of 1 or 2 indicate mild and severe blanching. Values of 3 or above indicate levels of bleaching with 3 meaning mild, 4 acute and 5 severe bleaching. The Cumulative Average result for each area is calculated as a single numerical value for each area. This value represents a general health value of the live tissue for the corals in an area. For this report a value of 1~6 is also used, with 1 being maximum stress, 6 being minimum stress (totally healthy).

## Data Presentation

A map showing the locations of the coral colonies tagged during this survey was included (Appendix B). Data for each colony were presented in table form. The CoralWatch data results were presented as bar graphs for each area with the cumulative area average shown as a single figure also for each area.



## RESULTS

The data has been separated into three groups – Impact, Control and Translocate. There is also a comparison between the Baseline data and the Final Survey data sets.

The CoralWatch data has been expanded to include the change in Cumulative Average (CA) results for each area. This allows the seasonal changes to be compared in different areas.

It should be stressed that Typhoon Prapiroon required the re-establishment of the Control colonies. Whilst this did not undermine the integrity of the monitoring survey, it meant that a sudden dip in the CoralWatch CA value was recorded in August 2006 (Impact Survey 7).

### Tagged Impact Coral Colonies

A total of 15 coral colonies were tagged for impact monitoring for this project. These colonies were located nearby to the in-water works area (see Appendix B1 and B2). Colonies tagged were deemed suitable to indicate any impact to the surrounding coral communities from this work. Details of the current state of the tagged colonies with the original baseline data are included in Table 2. Physical appearance of the impact colonies were photographed and are presented in Appendix C1 along with those taken during the baseline survey last year.

**Table 2. – List of the Impact Coral Colonies tagged and their final monitored data together with baseline results.**

Tag	Species	Baseline Results				Final Monitoring Results				
		Size cm <sup>2</sup>	Sediment		Colour	Partial Mort.	Sediment		Colour	Partial Mort.
I1	<i>Platygyra acuta</i>	250	5	Fine	CV406	0	5	Fine	CV406	5
I2	<i>Platygyra acuta</i>	260	5	Fine	CV406	5	5	Fine	CV406	0
I3	<i>Platygyra acuta</i>	240	5	Fine	CV406	0	0	\	\	0
I4	<i>Platygyra acuta</i>	210	5	Fine	CV406	0	0	\	\	0
I5	<i>Porites lobata</i>	150	5	Fine	CV406	0	0	\	\	0
I6	<i>Montipora venosa</i>	95	10	Fine	CV406	5	5	Fine	\	5
I7	<i>Pavona decussata</i>	55	0	\	\	5	0	\	CV406	0
I8	<i>Platygyra acuta</i>	200	5	Fine	CV406	5	0	\	\	5
I9	<i>Hydnophora exesa</i>	90	0	\	\	0	0	\	\	0
I10	<i>Favia rotumana</i>	120	5	Fine	CV406	5	0	\	\	0
I11	<i>Platygyra acuta</i>	110	5	Fine	CV406	5	0	\	\	0
I12	<i>Lithophyllon undulatum</i>	270	5	Fine	CV406	10	0	\	\	5
I13	<i>Favia speciosa</i>	170	10	Fine	CV406	5	5	Fine	CV406	5
I14	<i>Leptastrea purpurea</i>	250	10	Fine	CV406	0	0	\	\	0
I15	<i>Favia rotumana</i>	190	0	\	\	0	0	\	\	0

Note (1) CV406 is a light grey colour  
 (2) I1 has been replaced by I1a after the barge incident of species *Favia rotom*

A comparison of CoralWatch for these colonies between baseline and recent data is in Figure 2. The Cumulative Average was calculated to be 3.95 for this survey, whereas that of baseline was 4.57. A historical Cumulative Average was also included (Fig.3). Note that the Cumulative Average figure has a range from 1~6 with 6 being no stress and 1 being maximum stress.

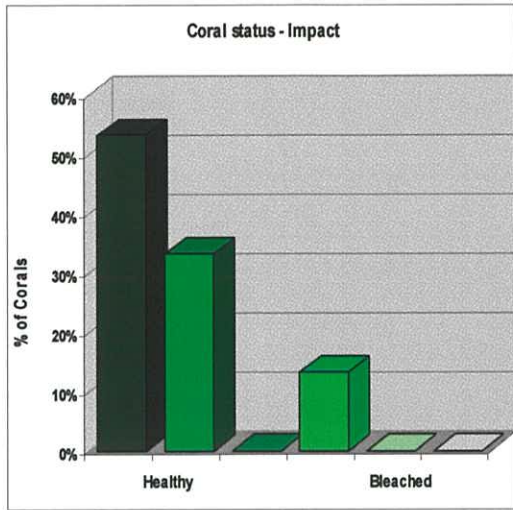


Figure 2a. The baseline CoralWatch result for the Impact Colonies.

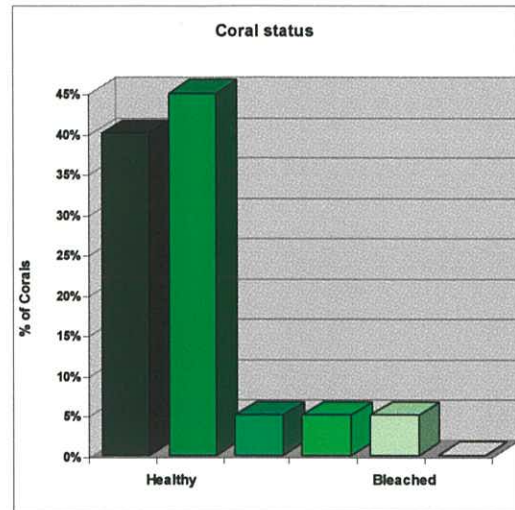


Figure 2b. The final CoralWatch result for the Impact Colonies.

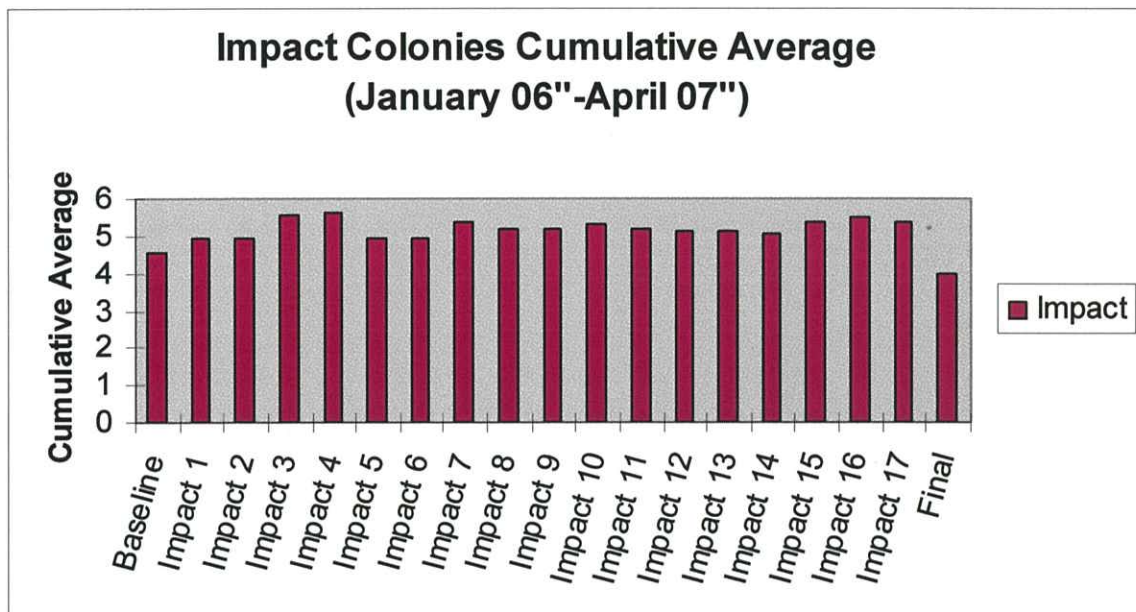


Figure 3. Respective Cumulative Average data recorded for Impact Colonies from baseline survey until final monitoring survey.

### Tagged Control Coral Colonies

A total of 15 coral colonies were tagged for control monitoring for this project. These colonies were located at least 100m either side of the works area (see Appendix B). Colonies tagged were deemed suitable to be used as a reference to determine any background changes in the coral community. The list of data of the corals is in Table 3 as well as the baseline

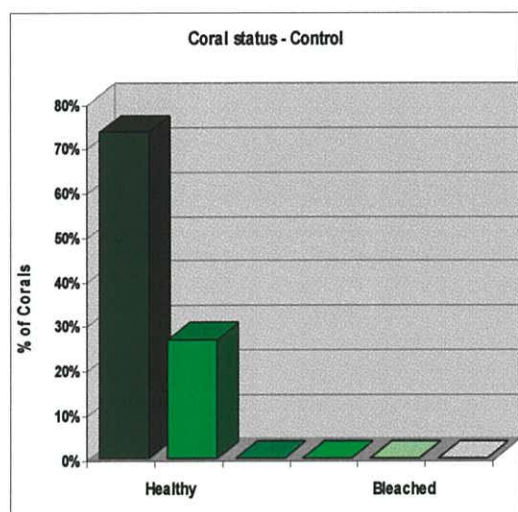
data. A map showing the locations is in Appendix B1 and B2. A physical comparison on the individual control colonies were presented in Appendix C2 against photographs took approximately a year ago.

**Table 3. – List of the Control Coral Colonies tagged with their relative baseline and recent survey results.**

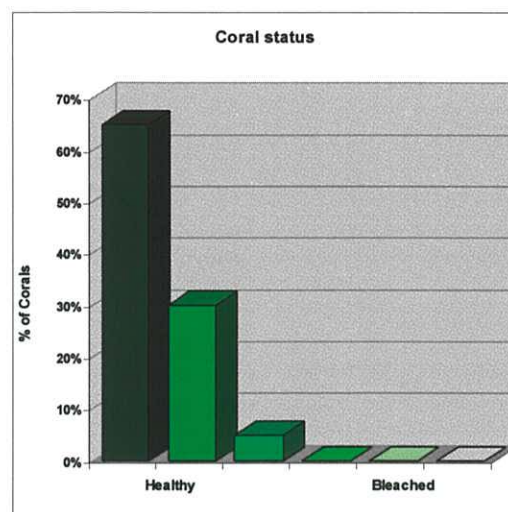
Tag	Species	Baseline Results				Partial Mort.	Final Monitoring Results				Location See Note 2
		Size cm <sup>2</sup>	%	Sediment Type	Colour		%	Sediment Type	Colour	Partial Mort.	
C1	<i>Favia veroni</i>	260	5	Fine	CV406	5	0	\	\	0	A
C2	<i>Favia veroni</i>	190	5	Fine	CV406	5	0	\	\	0	A
C3	<i>Favia speciosa</i>	180	0	\	\	5	0	\	\	5	A
C4	<i>Leptastrea pruinosa</i>	260	5	Fine	CV406	0	0	\	\	0	A
C5	<i>Platygyra camosus</i>	380	0	\	\	5	0	\	\	0	A
C6	<i>Favia speciosa</i>	250	0	\	\	5	0	\	\	0	A
C7	<i>Porites lobata</i>	380	5	Fine	CV406	10	0	\	\	5	A
C8	<i>Platygyra acuta</i>	250	0	\	\	0	0	\	\	0	A
C9	<i>Leptastrea purpurea</i>	290	5	Fine	CV406	5	0	\	\	0	B
C10	<i>Platygyra camosus</i>	260	1	Fine	CV406	0	0	\	\	0	B
C11	<i>Leptastrea purpurea</i>	260	10	Fine	CV406	5	0	\	\	0	B
C12	<i>Platygyra acuta</i>	140	0	\	\	0	0	\	\	0	B
C13	<i>Platygyra acuta</i>	150	10	Fine	CV406	0	0	\	\	0	B
C14	<i>Favia veroni</i>	210	5	Fine	CV406	0	5	Fine	CV406	0	B
C15	<i>Platygyra acuta</i>	220	0	\	\	0	0	\	\	0	B

Note (1) CV406 is a light grey colour  
 (2) C9~C15 have been damaged during the barge incident and replaced by C9a~C15a  
 (3) Refer to Appendix B

The CoralWatch data for these colonies is in Figure 4. The recorded data from baseline survey to post monitoring survey was presented in Figure 5. The Cumulative Average was calculated to be 4.15 as compared to 4.47 in 2006 when baseline data was obtained. Note that the Cumulative Average figure has a range from 1~6 with 6 being no stress and 1 being maximum stress.



**Figure 4a. The baseline CoralWatch result for the Control Colonies.**



**Figure 4b. The final CoralWatch result for the Control Colonies.**

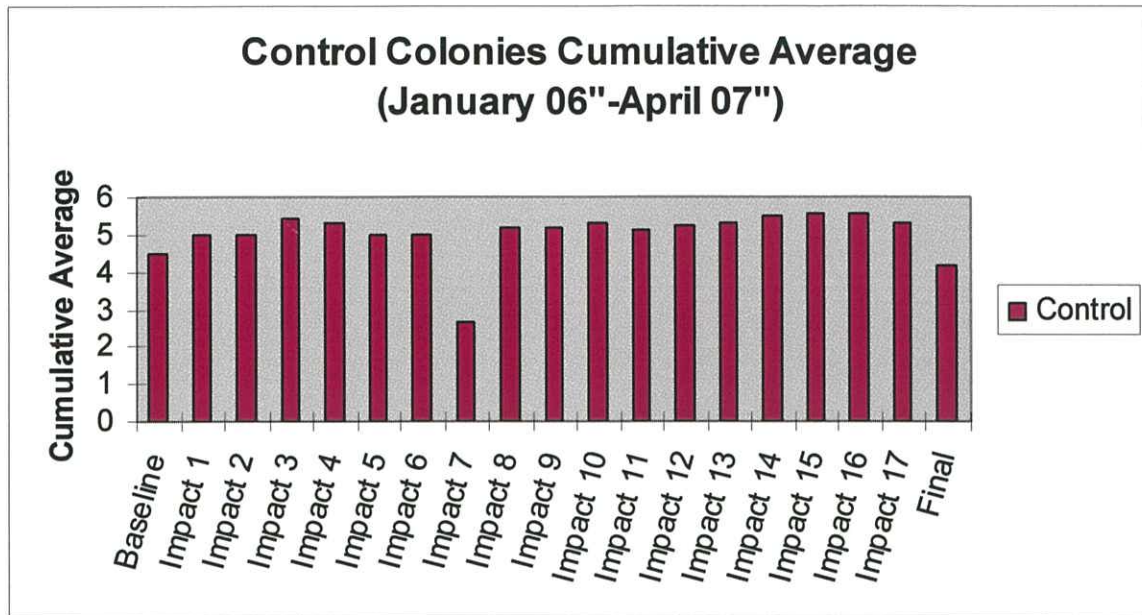


Figure 5. Respective Cumulative Average data recorded for Control Colonies from baseline survey until final monitoring survey.

Note that the sudden drop in CA during Impact Survey 7 was due to Typhoon Prapiroon.

### Tagged Translocated Coral Colonies

Fifteen colonies were tagged for monitoring as previously stated. These are listed in Table 4. This survey results on each of the selected colonies is also included in Table 4 as well as the respective data recorded during baseline survey. A photograph of each tagged colony is in Appendix C3 with the corresponding photograph taken last year during the baseline survey as a comparison. A map showing the location is in Appendix B2 and B3.

Table 4. – List of the Relocated Coral Colonies tagged in Core Area A and their survey results.

Tag	Species	Baseline Results				Final Monitoring Results				
		Size cm <sup>2</sup>	Sediment %	Type	Colour	Partial Mort.	Sediment %	Type	Colour	Partial Mort.
T1	<i>Leptastrea purpurea</i>	230	0	\	\	5	0	\	\	0
T2	<i>Platygyra acuta</i>	150	0	\	\	3	0	\	\	0
T3	<i>Leptastrea purpurea</i>	230	0	\	\	5	0	\	\	0
T4	<i>Platygyra acuta</i>	95	0	\	\	10	0	\	\	0
T5	<i>Favia rotomana</i>	140	0	\	\	0	0	\	\	0
T6	<i>Porites lobata</i>	130	0	\	\	10	0	\	\	0
T7	<i>Pavona decussata</i>	19	0	\	\	5	0	\	\	0
T8	<i>Platygyra acuta</i>	190	0	\	\	5	0	\	\	0
T9	<i>Psammocora haimeana</i>	80	0	\	\	5	5	\	CV406	5
T10	<i>Porites lobata</i>	90	0	\	\	1	0	\	\	0
T11	<i>Platygyra acuta</i>	210	0	\	\	5	0	\	\	0
T12	<i>Platygyra acuta</i>	210	0	\	\	5	0	\	\	0
T13	<i>Platygyra acuta</i>	140	0	\	\	5	5	\	CV406	0
T14	<i>Cyphastrea serailia</i>	150	0	\	\	5	0	\	\	0
T15	<i>Platygyra acuta</i>	95	0	\	\	10	0	\	\	5

Note (1) CV406 is a light grey colour

The results of the survey are in Figure 6b with the relative results from last year in Figure 6a. The Cumulative Average dropped from a value of 4.03 to 3.98 at this monitoring. Cumulative Average data from all the surveys done can be found in figure 7. Note that the Cumulative Average figure has a range from 1~6 with 6 being no stress and 1 being maximum stress.

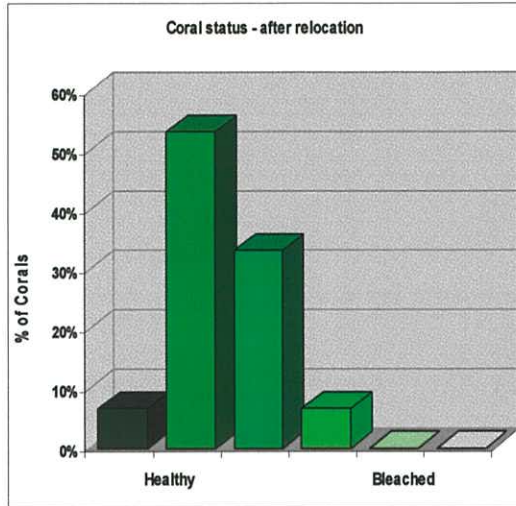


Figure 6a. CoralWatch results after the relocation in April 2006.

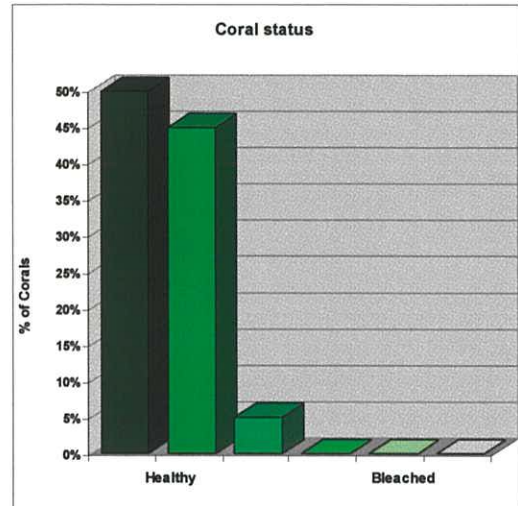


Figure 6b. CoralWatch, current surveyed status of the Relocated Corals.

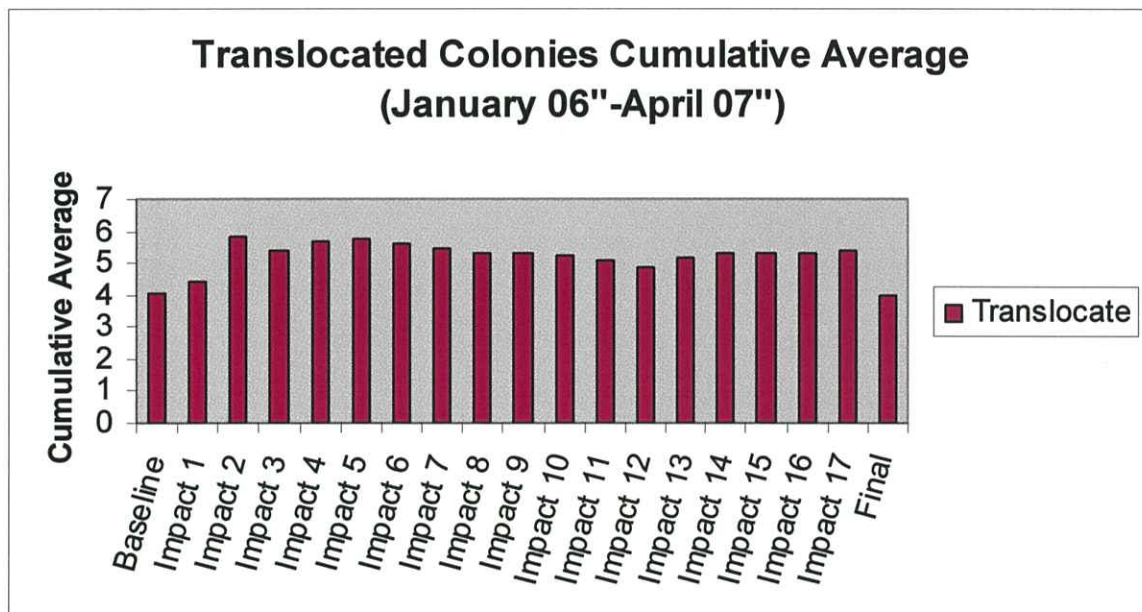


Figure 7. Respective Cumulative Average data recorded for Translocate Colonies from baseline survey until final monitoring survey.

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## DISCUSSION

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All of the coral areas around the works area survived with minimal impact from the works. Only one colony (tagged colony I8), other than those damaged during Typhoon Prapiroon, was found dislodged during impact survey 17 however it is not possible to determine that the works were the reason why the colony separated from its substratum. The colony has already been re-attached.

It is important to balance public safety with conservation for necessary maintenance, renovation, improvement and construction works in ecologically sensitive areas.

This is very true when providing safe public access to gazetted protected areas.

The renovation of the Tung Ping Chau Pier involved carrying out both construction and renovation works in a sensitive coral area. The work was considered necessary because the old pier was literally falling apart and with the increasing number of visitors to the area, public safety was becoming a concern.

In order to facilitate the work with a minimum amount of impact to the surrounding area several mitigation measures were adopted:

1. Relocation of the coral colonies inside the immediate work area (41 colonies).
2. Installation of a sediment curtain.
3. Periodic monitoring of tagged coral colonies during the entire work period.

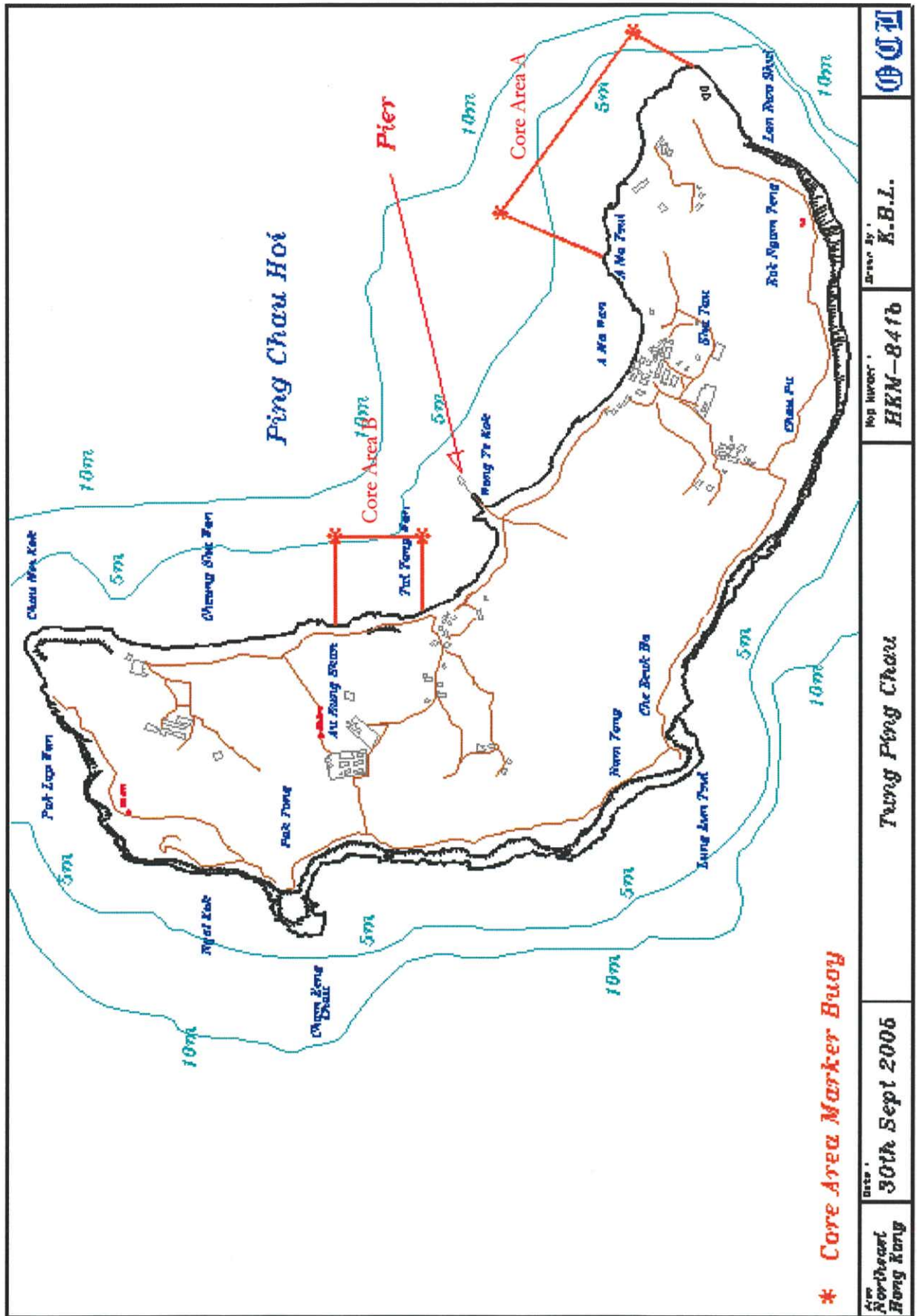
The fact that this work was carried out in an area that contained corals and was surrounded by corals presented challenges. The latest techniques of coral relocation-substratum transplantation using coral friendly cement, and the CoralWatch survey to detect change and to monitor the work rate on the corals helped considerably. The work included the addition of two caisson piles. These were added within 3m of significant areas of coral colonies. The rock clearing, vibration sinking and concreting of these piles was carried out very carefully. The surrounding coral areas were unaffected.

A severe typhoon, Typhoon Prapiroon, struck the area in August causing considerable damage to several coral areas within the Tung Ping Chau Marine Park. Over the course of this project these were mitigated as well.

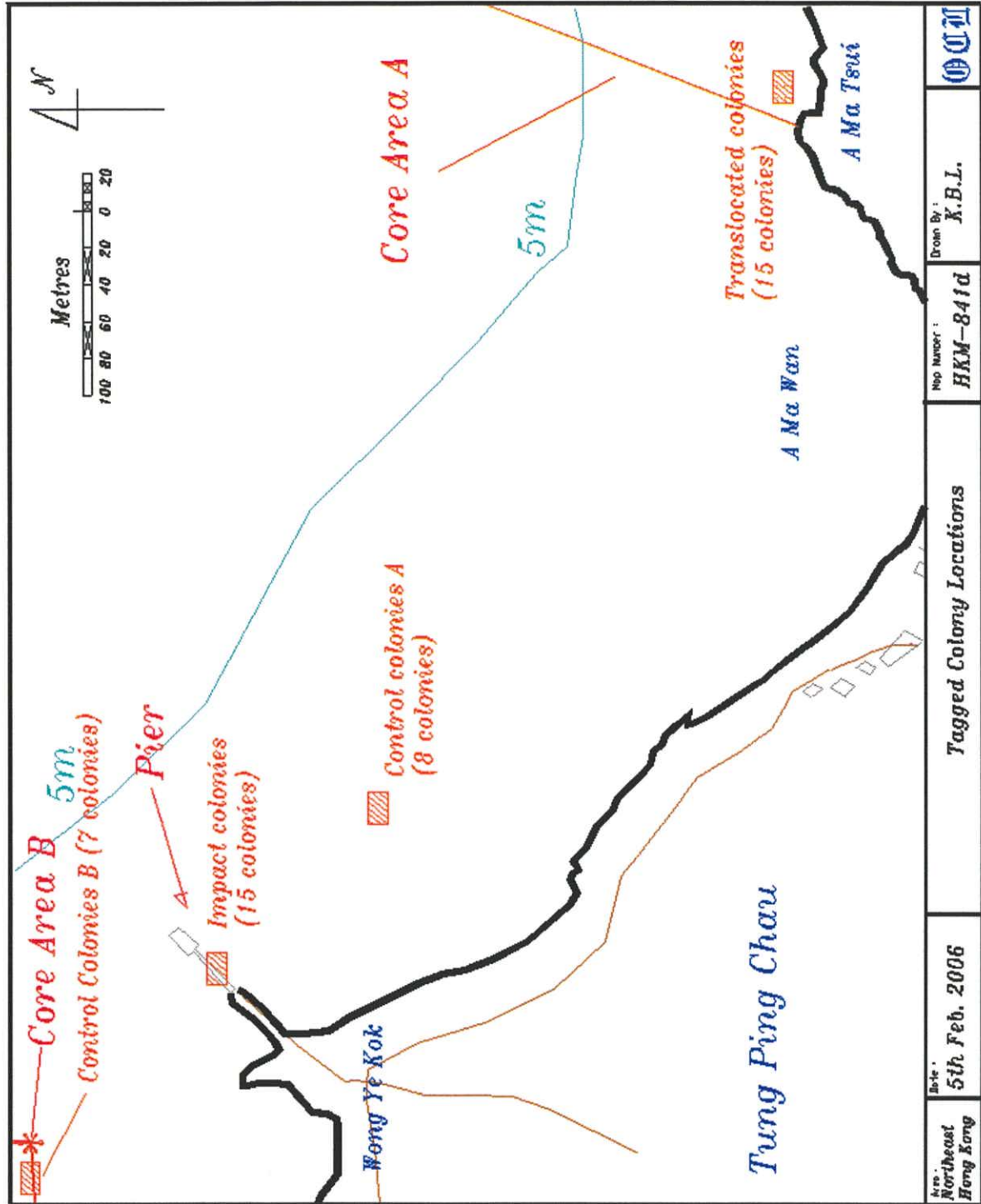
Overall this project serves as a model of future works that may need to be carried out in sensitive marine areas. It is highly likely that other piers will need renovation or need to be built in the future. After this project there is no reason why even encrusting corals cannot be relocated minimizing the impact the works may have on areas surrounding the works.

A collection of general photographs are included in Appendix D.

APPENDIX A - TUNG PING CHAU MAP

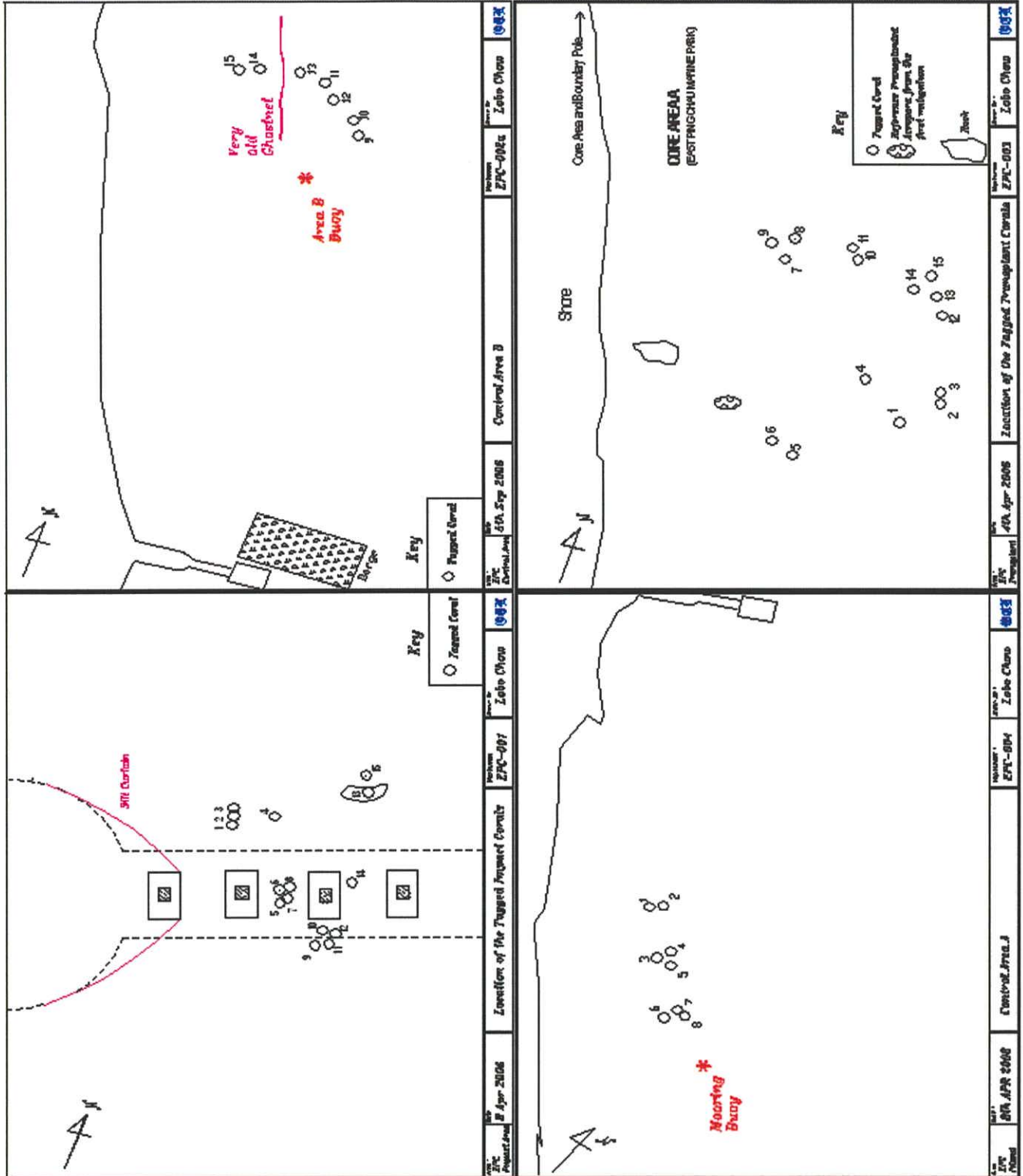


APPENDIX B1 - LOCATION OF THE TAGGED CORAL AREAS







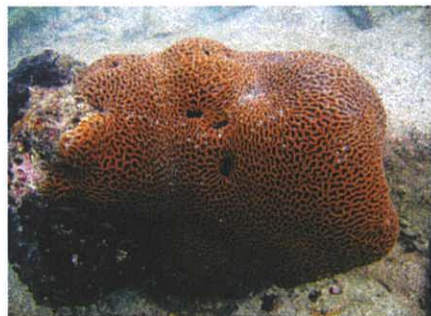






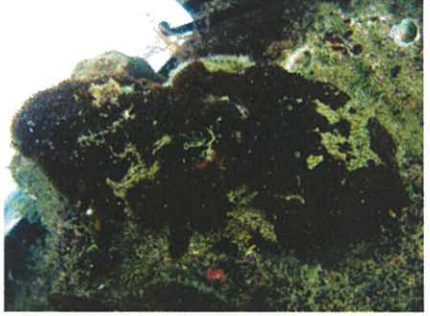


















APPENDIX B2 – LOCATION OF THE TAGGED CORALS WITHIN EACH AREA





**APPENDIX C1 – TAGGED COLONIES (IMPACT)**

Baseline		Post-monitoring	
	I1		I1a
	I2		I2
	I3		I3
	I4		I4

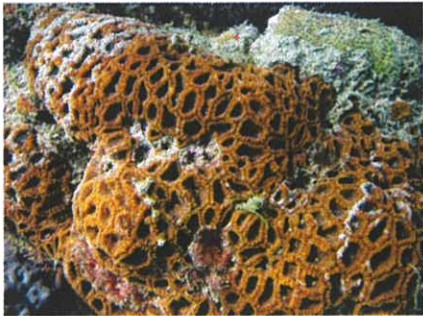
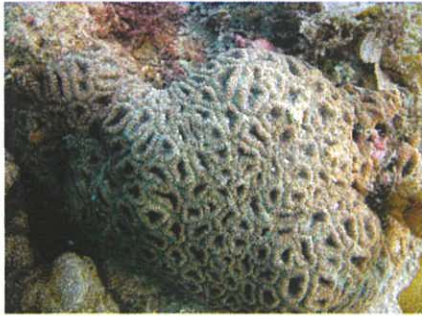






	<p>I5</p>		<p>I5</p>
	<p>I6</p>		<p>I6</p>
	<p>I7</p>		<p>I7</p>
	<p>I8</p>		<p>I8</p>
	<p>I9</p>		<p>I9</p>











	I10		I10
	I11		I11
	I12		I12
	I13		I13
	I14		I14











 A photograph of a coral specimen, identified as I15. The coral is a branching, yellowish-brown structure with a porous, lattice-like appearance. It is set against a dark background with some green and blue elements, possibly other coral or seaweed.	I15	 A photograph of a coral specimen, identified as I15. This coral is a branching, brownish-orange structure with a porous, lattice-like appearance. It is set against a dark background with some blue and green elements.	I15
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Note: Coral tagged I1 has been replaced by I1a after the typhoon incident in August 2006.

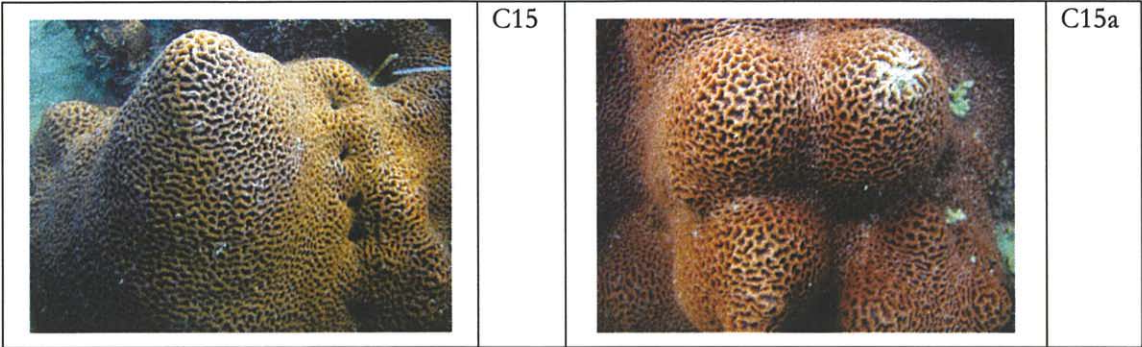
**APPENDIX C2 – TAGGED COLONIES (CONTROL)**

Baseline		Post-monitoring	
	C1		C1
	C2		C2
	C3		C3
	C4		C4

	<p>C5</p>		<p>C5</p>
	<p>C6</p>		<p>C6</p>
	<p>C7</p>		<p>C7</p>
	<p>C8</p>		<p>C8</p>
	<p>C9</p>		<p>C9a</p>









	C10		C10a
	C11		C11a
	C12		C12a
	C13		C13a
	C14		C14a










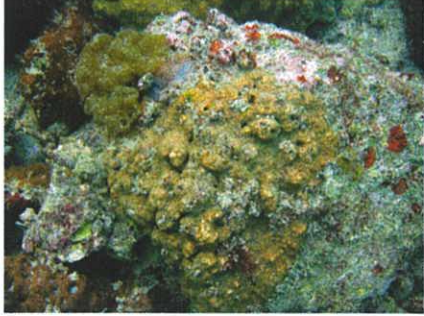



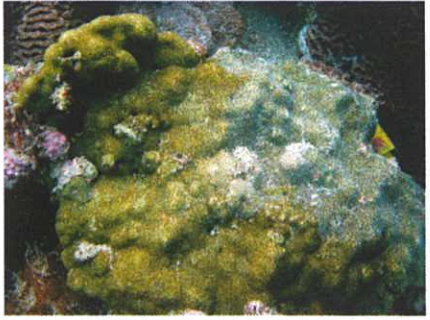












Note: Corals tagged C9, C10, C11...C15 have been replaced by C9a, C10a, C11a...C15a after the typhoon incident in August 2006.

**APPENDIX C3 – TAGGED COLONIES (TRANSLOCATION)**

Baseline		Post-monitoring	
	T1		T1
	T2		T2
	T3		T3
	T4		T4

	T5		T5
	T6		T6
	T7		T7
	T8		T8
	T9		T9

	T10		T10
	T11		T11
	T12		T12
	T13		T13
	T14		T14

	T15		T15
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APPENDIX D – PHOTOGRAPHS FOR PIER RENOVATION



**Plate 1.** The new look Tung Ping Chau Pier.

(March 2007)



**Plate 2.** The old pier before the renovation works began.

(January 2006)



**Plate 3.** The area was tagged for identifying purpose with Perspex tags.

(January 2006)



**Plate 4.** Removing a small encrusting coral from the pier foundation before the works started.

(January 2006)



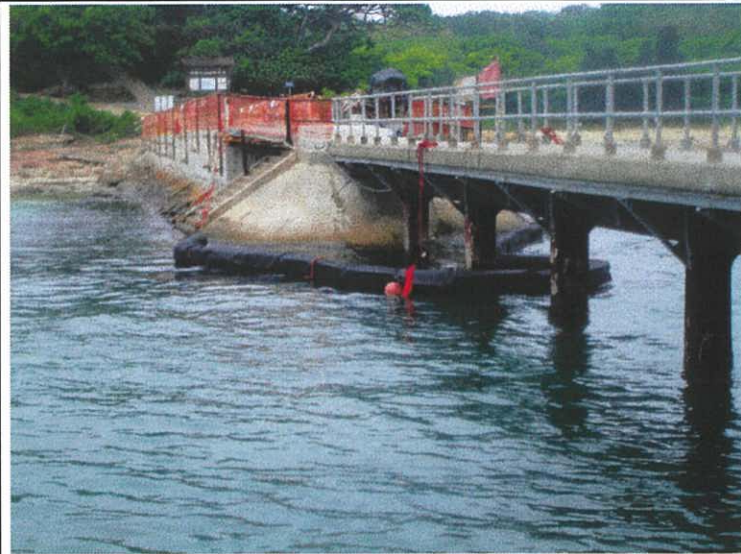
**Plate 5.** The same coral as in Plate 4 above. Now removed. This coral colony was one of the 41 relocated to another area.

(January 2006)



**Plate 6.** The location of the Works Barge. The addition of this vessel allowed the pier to be kept clear of construction equipment and debris.

(April 2006)



**Plate 7.** A sediment curtain was added to limit the fallout of sediment and to contain any concrete overspill. There were coral colonies within 2m of this curtain.

(April 2006)



**Plate 8.** The landing point for the old pier.

(May 2006)



**Plate 9.** A diver working inside the sediment curtain removing rocks so that the caisson piles could be installed under the pier.

(May 2006)





**Plate 10.** Coordination of the temporary removal of the burnishing stones from the foot of the old pier. These rocks were lifted out one by one.

(May 2006)



**Plate 11.** A diver working with the crane operator to remove the rocks around the old pier structure. Some of these rocks weighted nearly one tonne.

(May 2006)



**Plate 12.** A foundation rock being lifted out.

(May 2006)



**Plate 13.** Reinforcing the pier footing to allow it to take the weight of the new pier section.

(May 2006)



**Plate 14.** A view of the worksite showing the installation of the guides for the caisson piles.

(May 2006)



**Plate 15.** The Work Barge for this project. All material had to be kept in the hold to ensure that nothing could fall onto the corals below.

(May 2006)



**Plate 16.** The deeper foundation for the caisson piles was dug using a rock grab. Both surface and in water guiding of this work phase was carried out.

(May 2006)



**Plate 17.** The rock grab in action. Only one day was required for this work.

(May 2006)



**Plate 18.** The caisson guides were used to align the grab. Note the effectiveness of the sediment curtain.

(May 2006)



**Plate 19.** Accurate grabbing within metres of a coral area. This work was supervised from the surface in-water. No coral damage resulted. A similar technique had been applied during the Pak A project.

(May 2006)



**Plate 20.** Finally the first caisson goes in. It was gently vibrated through the sand until it reached firm bed-rock.

(May 2006)



**Plate 21.** The pier was not closed to the public during this renovation so there were limited areas on the pier for the construction crew to work. This is one such area.

(May 2006)



**Plate 22.** The old pier with the Working Barge.

(May 2006)



**Plate 23.** The pier during a busy day. Garbage bins were kept nearby to help keeping the area clean.

(January 2007)



**Plate 24.** A photograph along the new pier. Only some of the railings had not been installed.

(March 2007)



**Plate 25.** Along the new pier.  
(March 2007)



**Plate 26.** Looking towards the end of the new pier.  
(March 2007)



**Plate 27.** Underneath view of the new pier. The two caissons are shown in this photograph.  
(April 2007)



**Plate 28.** A closer view of the new pier.

(April 2007)



**Plate 29.** The far end of the new pier.

(April 2007)



**Plate 30.** The completed product. A new pier at Tung Ping Chau.

(April 2007)