SINGAPORE REEF SURVEY AND CONSERVATION PROJECT

A PROPOSAL FOR THE CONSERVATION OF CORAL REEFS IN SINGAPORE

Presented by :

REPUBLIC OF SINGAPORE YACHT CLUB
SINGAPORE INSTITUTE OF BIOLOGY
SINGAPORE UNDERWATER FEDERATION

With the support of :

SINGAPORE SEA SPORTS LIAISON COMMITTEE
NATIONAL COUNCIL ON THE ENVIRONMENT

JULY 1991

TABLE OF CONTENTS

I. INTRODUCTION

As a small island nation, urbanising at a rapid rate and supporting the world's busiest port, Singapore's limited seaspace has become one of the most intensively used in the world. Despite this, the waters support coral reefs, all remaining of which are associated with the Southern Islands. All of these reefs have been adversely affected by increased sedimentation and other causes due to human activities over the past three decades. As a result, the deeper zones have been devastated, but surprisingly the shallower zones continue to support an amazingly high species diversity and good coral growth. They are, however, under serious threat of extinction, if there is no concerted action taken to preserve them.

The present condition of our reefs merit urgent consideration, as it is a beautiful and fascinating natural heritage, with its own inherent worth. It is also useful to science, education, tourism and recreation, as well as affording the government a unique opportunity to showcase its already exemplary management of the environment, in other respects. By having the better reefs conserved within intensively utilised waters, Singapore can serve as an example of a developing country which, in spite of its limited geography, is still able to devote attention to the conservation of some of its coral reef resources.

There is at present an apparent lack of appreciation of our coral reefs. Development plans for the Southern Islands place near-total emphasis on the landscape. What is present below sea level is given little consideration, except for engineering concerns. It is accepted that some of the reefs will have to make way for development which is in the nation's

interest. An effective strategy would be to make use of the poorer reefs for the necessary development and to take steps to conserve the better reefs for posterity.

II. THE SINGAPORE REEF SURVEY AND CONSERVATION PROJECT

With this rationale in mind, three national non-profit organisations got together in 1987, long before issues on the environment became fashionable, to do something about it. The Republic of Singapore Yacht Club (RSYC), Singapore's oldest and only comprehensive sea sports club; The Singapore Underwater Federation (SUF), Singapore's national sports association for diving; and The Singapore Institute of Biology (SIBiol), the national institute for biologists; launched the Reef Survey and Conservation Project. It was supported by the Singapore Sea Sports Liaison Committee, which represents a cross-section of Singapore's National Sea Sports Clubs and Associations.

The project was mooted by the RSYC and prompted by the shared increasing concerns by each of the organisations involved, that unless something concrete is done by the government to halt the wanton or unwitting destruction of our reefs, and sustained steps are taken to promote the appreciation of our reefs and marine life, Singapore will forever lose a crucial and beautiful part of its natural heritage.

Terms of reference for the project were adopted in early 1988 and a copy of the same is annexed, for information (Annex 1). The project was in the main, undertaken in three phases:

PHASE 1. TRAINING

In order that the Project Committee can gather scientific information on our reefs, using an internationally accepted sampling survey method, it was necessary to have

trained personnel. For this to be possible, a pool of volunteer SCUBA divers had to be recruited, trained and qualified to undertake the surveys. The SIBiol and SUF formulated an original special course, the contents of which focused on basic knowledge of marine life, diving techniques and survey methodology. A corps of diving instructors was trained as Ecology Specialty Instructors. Then, volunteer certified sports divers were put through classroom instructions, pool sessions and open-water training, followed by theory and practical assessments, before being certified by the SUF as Reef Ecology Specialty Divers, a certification unique and original to Singapore, and probably the world. Although the aim was to train 100 such divers, almost 150 were trained and certified in 1988 and 1989. The response of diving instructors, divers and diving clubs in Singapore generally was very encouraging. The course can be easily adapted to create awareness among all sport divers, biologists, students and others interested in marine life, as well as for the training of public officers, who may be required to administer the marine parks, should these be created.

PHASE 2. SURVEYS

With the trained manpower available, Reef Ecology Specialty Divers were deployed into ten teams and detailed to survey selected sites on our reefs in the Southern Islands. The teams rented boats to go out to the reefs and conduct these surveys. A few skippers in the RSYC also volunteered themselves and their boats for such field surveys. Each of some 65 sites on 41 reefs, were painstakingly surveyed, between 1988 and 1990. The survey technique essentially involved laying an underwater tape, along a transect of 100 metres at the reef crest (considered 0m depth) and then at 3m

depth at the same spot. Divers then identifed everything that were intersected by the tape, describing their condition and recording it. By these means, scientific data of a total of some 13,000 metres of reefs (half at 0m depth and half at 3m depth) were gathered. These data were then checked and analysed by marine biologists under SIBiol, and collated with the aid of a personal computer.

PHASE 3. REPRESENTATIONS

This involves the putting together of this report and proposal for the submission to the government for its kind consideration and urgent action.

III. RESULTS

The amount of live coral cover found can be taken as a simple and reliable indicator of the condition of a reef. The percentage live coral cover at the reef crest was then grouped into 4 categories and classified according to their condition:

Group	% of Live Coral Cover	Condition
Category A.	more than 70.00 %	Excellent
Category B.	between 50.01 and 70.00 %	Good
Category C.	between 30.01 and 50.00 %	Fair
Category D.	less than 30.00 %	Poor

The results of the reefs surveyed are shown in Tables 1 and 2 and also illustrated in Figure 1.

At the reef crest (0m), the live coral cover ranged from 3.63% to 75.29% (Table 1) for all reefs surveyed. The highest percentage cover was recorded at Raffles Lighthouse, while the lowest at the patch reef of Beting Bemban Besar. Live coral cover at the 3m depth ranged from 0% to 68.27% (Table 2) for all surveyed reefs, with the highest cover recorded at the patch reefs west of Pulau Semakau and the lowest at Pulau Sebarok. The results indicated that about three quarters of the coral reefs surveyed still supported 30% or more of live coral cover at the reef crest. At some of these reefs, the corresponding results for the 3m depth were also comparable to that of the reef crest. From the results, it can be seen that

reefs with the better live coral cover occurred in four major areas: Areas 1, 2, 3 and 4 (Figures 2a, 2b, 2c & 2d):-

Area 1. Pulau Hantu and the patch reefs west of the island, including Terumbu Pempang Laut, Terumbu Pempang Tengah and Terumbu Pempang Darat (Figure 2a).

Area 2. The islands of Lazarus, St. John's and The Sisters (Figure 2b).

Area 3. The Northern and the Western coast of Pulau Semakau and the patch reefs including Terumbu Raya, Terumbu Bemban, Beting Bemban Besar, Terumbu Palat and Terumbu Menalung, to the Eastern border of the Live Firing/Restricted Zone (Figure 2c).

Area 4. Pulau Salu to the North West, Pulau Sudong, Pulau Pawai, Pulau Senang, Pulau Biola and Raffles Lighthouse to the South, including the patch reefs between these islands (generally within the Live Firing or Restricted Zone, which made access limited and therefore reduced the number of the sites surveyed) (Figure 2d).

The condition of the coral reefs in these four areas make them worthwhile for some form of conservation and management. A large database has been generated through this survey and much more information, such as the extent of dead coral cover, algal cover, other

reef organisms, the substrate quality and the diversity of coral growth forms, for each of the surveyed reefs, is available. This information is too voluminous to be reproduced in this report but will certainly be made available for the government. How these four areas can be delineated and used, will be dealt with later in this report.

IV. ISSUES CONCERNING OUR REEFS

Despite massive and highly successful measures to control pollution on land, regulations affecting the dumping of earth spoils in the sea are woefully inadequate. There is also almost no regulation governing the removal of corals and other reef organisms from our reefs. This situation has been prone to neglect, abuse and exploitation, by various users and the public. If any measure is to succeed, those two key issues must be addressed.

The first key issue and indeed, the chief cause of the decline of our reefs, is the dumping of earth spoils and sediment-bearing solids, and the way it is carried out. It is unclear to us how much dumping has taken place and is taking place, but from the effects, it has been and is extensive. For example, tugboats tow barge-fulls of spoils, such as those from MRT tunnelling and other earth works, which are loaded via conveyer belt off Marina South or from other excavation and dredging sites, to dump them haphazardly in a wide area South and East of Pulau Semakau. One often sees excavators pushing the spoils from the barge above the water's surface, sometimes while the barge is still on the way, causing a high degree of pollution and siltation over a wide area. The reefs east of P. Semakau have been badly affected, but since this area has been designated for future disposal of solid wastes, the loss may be academic. However, the reefs west of P. Semakau, which are among the better ones, are also receiving the effect of the increased sedimentation. The impact can be minimised by having it more localised. This would mean that the present method of dumping will have to be reviewed, so that the earth spoils can be sent direct to the seafloor as quickly as possible and only at carefully designated and controlled locations. The Ministry of Environment should be applauded for its insistence on environmental impact studies, in

connection with the building of a solid bund to contain solid waste East of P. Semakau in the future. The government should strictly control all present dumping of earth spoils and perhaps insist on the construction of solid bunds first to confine and localise the impact. However, much more needs to be done, especially where dredging and reclamation works are contemplated near reef sites. Environmental impact studies should be made compulsory for all projects.

A second key issue is the indiscriminate removal of fish on an unmanaged basis. Coral reefs can support subsistence fishing on a non-intensive scale. However, when the intensity increases, with the accompanied use of barrier nets and fish traps, the removal rate of fishes will exceed the natural replacement rate. Food fishes and ornamental fishes are being constantly removed from our coral reefs, such that fish life is lacking in diversity and abundance, compared to reefs that do not face this pressure. Such removal is done mainly by commercial operators who lay large numbers of wire-mesh traps (called "bubus") or nets, and harvest them regularly. They also buy catches off fishermen who do so to supplement their income, or from sea-gypsies from Indonesia, who seem to be always around in Singapore waters and catching fish and collecting reef invertebrates from our reefs. These catches are sold to marine shops. This situation is analogous to allowing all plant and horticultural shops the liberty to remove plants from our natural parks and forests, for commercial sale.

The removal of corals and other reef organisms should be examined and carried out strictly on a managed basis, including where the Underwater World Sentosa and the Coralarium may be allowed to collect specimens for exhibits. Giant clams and shells of

ornamental value such as the Noble Volute and the Tiger Cowrie, have become exceedingly rare on our reefs. Other species in demand by the aquarium trade are hunted by collectors, some of which use destructive methods, such as the hacking of live corals to bits, in order to extract colourful shrimps and other invertebrates sheltering in them.

These and other issues can be largely addressed by a management or conservation plan.

V. CONSERVATION AND MANAGEMENT PLAN CONSIDERATIONS

The main aim of protecting identified coral reefs is to preserve a representative portion of this ecosystem. Endangered, depleted or rare species along with the ecosystem would also be protected and allowed to regenerate. Access to these protected areas should be controlled and regulated so that while it is accessible to education, scientific research, recreation and tourism, the ecosystem would be protected.

It is hoped that in the formulation of a management plan for the reefs, the following factors be considered. Site works and construction (tourist and industrial facilities) have immediate physical damage to parts of the reef. Water flow around the reef may be altered and such facilities may serve as a point source of pollution and littering. Anchor damage is a major cause of coral breakage and as such, the dropping of anchors in conserved areas should be prohibited, while temporary mooring facilities should be provided in and around these recreational areas. Sport divers who visit the coral reefs should be made aware of the fragility of corals and other reef species so that activities can be regulated to lessen the impacts on this ecosystem. Collection of living corals, shells and other reef organisms must be prohibited from any conserved area. Fish collection for commercial purposes from such areas, must also be prohibited. With the increase demand for sea sports in Singapore and ever shrinking areas in local waters for the purpose, a careful management will allow these pursuits to be enjoyed without jeopardising the very existence and survival of our reefs.

1. PARK DELINEATION, USES AND RESTRICTIONS

The four areas identified for conservation, contain a variety of coastal habitats, such as coral reefs, reef flats, sea-grass beds, sand flats, mangroves and beaches. They should be carefully delineated and gazetted as marine parks, under existing or new legislation, as may be appropriate. The government should be applauded for measures it has taken on land to consolidate the laws and administration of the parks and reserves. This should be extended to the four marine conservation areas. Appropriate regulations should be drawn up to allow for legitimate uses but to outlaw destructive uses.

(A) Educational and Scientific

Schools and colleges can organise educational excursions to these reefs, under proper supervision. Bona fide scientific research should be encouraged.

(B) Recreational and Touristic

Compatible uses in these areas can indeed include recreation and tourism, provided these too are carried out responsibly. These activities can include snorkelling, SCUBA-diving, line or rod fishing and spearfishing without the use of SCUBA. However all recreational fishing should be subjected to restrictions on the type and size of fish which can be taken, such as in countries which issue recreational fishing licenses. Underwater photography, reef appreciation, and guided tours along underwater nature trails, are other activities which can be permitted.

Some of the restrictions should include the removal of sand, coral, rock or marine life from the reefs. Standing, holding and breaking live coral colonies and the collection of such with its associated marine life should be prohibited.

Certain restrictions already exist in one of these areas, namely the Live Firing or Restricted Zone. These restrictions must, of course, be observed and in fact, may well contribute to the overall conservation of reefs within most of the areas concerned.

2. ENFORCEMENT AND MONITORING

As with forest reserves, rangers or wardens should be appointed. With the assistance of marine authorities, like the Marine Police, they can monitor usage and enforce the regulations.

The presence of one or more marine park ranger stations within the marine park areas, would help. From these vantage points, rangers will be able to monitor the areas. A system of punitive fines should also be implemented to discourage any violations. All four areas are already within the territory regularly covered by the marine police.

Monitoring, by surveys similar to what we have used and other non-destructive methods, should be carried out on a regular basis in the four areas for the purpose of determining any ecological changes within it, so that appropriate and timely action can be taken by the government.

3. EDUCATION AND INFORMATION DISSEMINATION

Video, film presentations, posters, colour pamphlets and publications, can be produced and distributed to all concerned and interested. Underwater trails can be laid in the Recreational Zones for underwater tours led by properly certified sport divers/volunteers. These measures will enable information concerning the objectives, uses and restrictions, to be disseminated to the general public. Increased awareness and education will enhance appreciation of our reefs and help conservation efforts in the long run.

4. ENHANCEMENT OF RESERVES

Once the basic management plan is in place, steps should also be taken to enhance the reserves; such as the installation of artificial reefs and the introduction of coral fishes. This will increase the variety and abundance of marine life, that will make them even more valuable and attractive.

VI. CONCLUSION

A plan, if implemented, would indeed be the start of a process to raise public awareness on the value of coastal resources as part of the environment of Singapore. It is also hoped that a conservation and management plan will promote marine/coastal research and environmental education, which would cater to the needs of the various users of our coastal resources, in order to maximize benefits and minimise conflicts.

The three organisations involved with this project will be more than willing to continue to provide whatever information, expertise and assistance, within their resources, towards the finalisation of a conservation and management plan for the coral reefs of Singapore and to assist in its implementation.

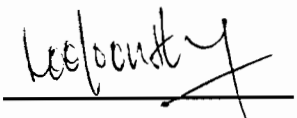
A copy of the one-page summary on mangroves, coral reefs and seagrasses of the World Wildlife Fund is annexed (Annex 5). Its contents underscore the importance, urgency and value of a national conservation plan for Singapore's reefs and related natural resources.

We therefore earnestly and respectfully urge the government to receive this report and adopt its proposals.

VII. LETTER OF SUBMISSION

RESPECTFULLY SUBMITTED TO THE GOVERNMENT OF SINGAPORE BY:

FRANCIS C H LEE
Chairman
Singapore Reef Survey and Conservation Project
Singapore Sea Sports Liaison Committee



LOO SOON HENG
Vice-Chairman, Singapore Reef Survey and Conservation Project
Commodore, Republic of Singapore Yacht Club

KHOO SOO SENG
Vice-Chairman, Singapore Reef Survey and Conservation Project
President, Singapore Underwater Federation

CHOU LOKE MING
Vice-Chairman, Singapore Reef Survey and Conservation Project
President, Singapore Institute of Biology

VIII. ACKNOWLEDGEMENTS

The project would not have come to fruition without the help of many people and organisations, all of whom share a noble concern for our natural heritage and environment, even before "green" issues became fashionable in Singapore. The Project Committee wishes to express its profound appreciation to each and every one of them, especially for their dedication, sacrifice, quiet commitment and gentle encouragement. It would not be possible to name every one exhaustively and any inadvertent omission is sincerely regretted. However, we would like to gratefully acknowledge the following, in particular:

A. Promoters

1. The successive Committees of RSYC, SUF and SIBiol, between 1987 and 1991, for their continuous support.

2. The Singapore Sea Sports Liaison Committee, for its support.

3. The RSYC, for inspiring the project, acting as Secretariat and advancing expenses needed till sponsors were found.

4. The SIBiol, for formulating the Reef Ecology Specialty Course, conducting the courses and for all the scientific inputs and extensive work undertaken, in every phase of the project.

5. The SUF, for helping in the diving aspects required of the course, qualifying and certifying divers, and also in helping out with the surveys.

6. The members of the Project Committee, for their leadership and service during the entire life of the project (Annex 2).

B. Diving Instructors and Divers

Without them, no underwater project is possible. They are the mainstay of the project. Coming from all walks of life, they (Annexes 3a & 3b) and their friends who volunteered as helpers (Annex 4), are excellent examples of volunteers, nationals and "world citizens", who care for the fragile environment and are prepared to contribute to conservation and nation-building.

C. Friends of Our Reefs

Several enlightened and environment-conscious organisations and persons have contributed "seed money", and in kind, to enable us to start up and complete the project. These include the following, whose contributions are gratefully acknowledged:

1. Sembawang Maritime Ltd, for its contribution of "seed money".

2. Pacific Architects & Engineering Pte. Ltd., for its contribution of "seed money".

3. Ancel Singapore Pte. Ltd., for donating prizes for a Reef Social and offering the use of remote underwater video equipment.

4. General Printing Services Pte. Ltd., for printing a flyer and tickets for a Reef Social.

5. Advanced Marine Pte. Ltd., for offering the use of remote underwater video equipment.

6. Dynaglass Reinforced Plastic Pte. Ltd., for offering the use of its special diving boat.

7. Reef Ecology Study Team, National University of Singapore, for providing underwater photographs, valuable advice and assistance.

8. Mr. G B de Souza, for inviting us to give a talk at Keppel Marina.

9. Mr. Stephen Seow and Mr. Yap Yoon Kee, for inviting us to give a talk at Rotary Club, Jurong Town.

10. Skippers of yachts in RSYC, for taking survey teams out and Mr Tan Kay Toh and Tan Kay Hum for the use of their compressors.

D. Project Sponsor

We are particularly grateful to Raffles Marina Ltd., for undertaking the main sponsorship of this project. As pioneers of modern marinas and leisure-related projects in and around Singapore, we cannot find a more eminent and ideal sponsor than the Natsteel group and Raffles Marina. They have underwritten the entire balance of the costs of the project.

TABLES

Table 1. Live hard coral cover at the reef crest (0 metre depth) Percentages are arranged in increasing order

Site	Island/Reef	%	Site	Island/Reef	%
R1	Raffles Light	75.29	TPA	Terumbu Palat	43.24
TPT	T. Pempang Tengah	73.91	J2	Pulau Jong	43.24
R2	Raffles Light	73.30	SEB2	Pulau Sebarok	42.32
HW2	Pulau Hantu	70.14	H3	Pulau Hantu	41.32
PSL2	The Sisters'	69.96	L3	Lazarus Island	41.87
TR1	Terumbu Raya	68.60	HW1	Pulau Hantu	41.45
SS2	Selat Sudong	66.27	SD1	Pulau Sudong	41.03
SU	Pulau Ular	66.15	BBN1	S. Bukom Beacon	39.04
TM	Terumbu Menalung	65.96	K2	Kusu Island	39.01
PSD1	The Sisters'	65.70	TR2	Terumbu Raya	38.19
SD2	Pulau Sudong	62.99	BB2	B. Beting Besar	36.06
L2	Lazarus Island	62.04	PS3	Pulau Seringat	35.01
TB1	Terumbu Bemban	60.09	PB2	Pulau Busing	33.67
TB2	Terumbu Bemban	59.15	K1	Kusu Island	33.11
SJ3	St John's Island	58.12	H1	Pulau Hantu	29.54
TPL1	T. Pempang Laut	57.73	SD3	Pulau Sudong	29.45
SJ1	St John's Island	57.60	BBN2	S. Bukom Beacon	29.30
TPL2	T. Pempang Laut	56.96	J1	Pulau Jong	28.64
B3	Pulau Busing	56.45	PS2	Pulau Seringat	27.10
PSL1	The Sisters'	56.39	B2	Pulau Busing	26.04
TSM1	Terumbu Semakau	53.80	S1	Pulau Semakau	25.97
PSD2	The Sisters'	53.54	TP2	Terumbu Pandan	21.43
SS1	Selat Sudong	52.95	C2	Terumbu Pandan	19.31
S2	Pulau Semakau	51.05	SCB2	S. Cyrene Beacon	17.79
SD4	Pulau Sudong	50.18	SEB4	Sebarok Beacon	15.50
SJ2	St John's Island	49.83	KB2	Kukor Beacon	12.07
EPS	Pulau Salu	49.74	S3	Pulau Semakau	12.00
BB3	B. Beting Besar	49.28	TP1	Terumbu Pandan	11.84
TPD2	T. Pempang Darat	47.47	PB1	Pandan Beacon	6.86
TPD1	T. Pempang Darat	46.09	TS	Terumbu Selegi	5.54
SEB1	Pulau Sebarok	45.65	C1	Terumbu Pandan	4.37
L1	Lazarus Island	45.29	TP3	Terumbu Pandan	3.63
H2	Pulau Hantu	43.76			

Table 2. Live hard coral cover on the reef slope (3 metre depth) Percentages are arranged in increasing order

Site	Island/Reef	%	Site	Island/Reef	%
TM	Terumbu Menalung	68.27	TPT	T. Pempang Tengah	22.59
HW1	Pulau Hantu	62.00	TPL2	T. Pempang Laut	22.29
TR1	Terumbu Raya	60.23	PSL2	The Sisters'	21.34
S2	Pulau Semakau	59.72	PB2	Pandan Beacon	18.60
TPD2	T. Pempang Darat	49.11	PSL1	The Sisters'	18.47
C2	Terumbu Pandan	48.06	SD2	Pulau Sudong	18.44
TB2	Terumbu Bemban	47.98	L1	Lazarus Island	17.65
H2	Pulau Hantu	46.23	SS1	Selat Sudong	17.55
BB3	B. Beting Besar	45.76	J2	Pulau Jong	15.28
R2	Raffles Light	45.20	BBN1	S. Bukom Beacon	15.24
TPL1	T. Pempang Laut	44.29	SJ2	St John's Island	14.99
S1	Pulau Semakau	42.09	SEB1	Pulau Sebarok	14.80
EPS	Pulau Salu	37.33	SD3	Pulau Sudong	14.79
BB2	B. Bemban Besar	35.08	TP3	Terumbu Pandan	14.10
TR2	Terumbu Raya	35.05	PSD1	The Sisters'	11.91
HW2	Pulau Hantu	35.01	BBN2	S. Bukom Beacon	10.60
SS2	Selat Sudong	33.67	S3	Pulau Semakau	10.32
PSD2	The Sisters	32.94	H3	Pulau Hantu	9.23
SU	Pulau Ular	32.73	PB1	Pandan Beacon	7.91
TPD1	T. Pempang Darat	31.47	SCB2	Cyrene Beacon	7.74
BB1	B. Beting Besar	31.32	L3	Lazarus Island	7.39
SJ3	St John's Island	31.09	TP1	Terumbu Pandan	7.08
SD1	Pulau Sudong	30.84	K1	Kusu Island	5.11
R1	Raffles Light	28.65	L2	Lazarus Island	2.43
TSM1	Terumbu Semakau	28.07	SJ1	St John's Island	2.17
SD4	Pulau Sudong	27.80	PS3	Pulau Seringat	2.09
H1	Pulau Hantu	27.66	TS	Pulau Selegi	0.90
B3	Pulau Busing	27.31	PS2	Pulau Seringat	0.78
TPA	Terumbu Palat	25.24	TP2	Terumbu Pandan	0.36
B2	Pulau Busing	23.80	J1	Pulau Jong	0.15
TB1	Terumbu Bemban	23.50	K2	Kusu Island	0.00
C1	Terumbu Pandan	23.50	SEB2	Pulau Sebarok	0.00
KB2	Kukor Beacon	22.75			

FIGURES

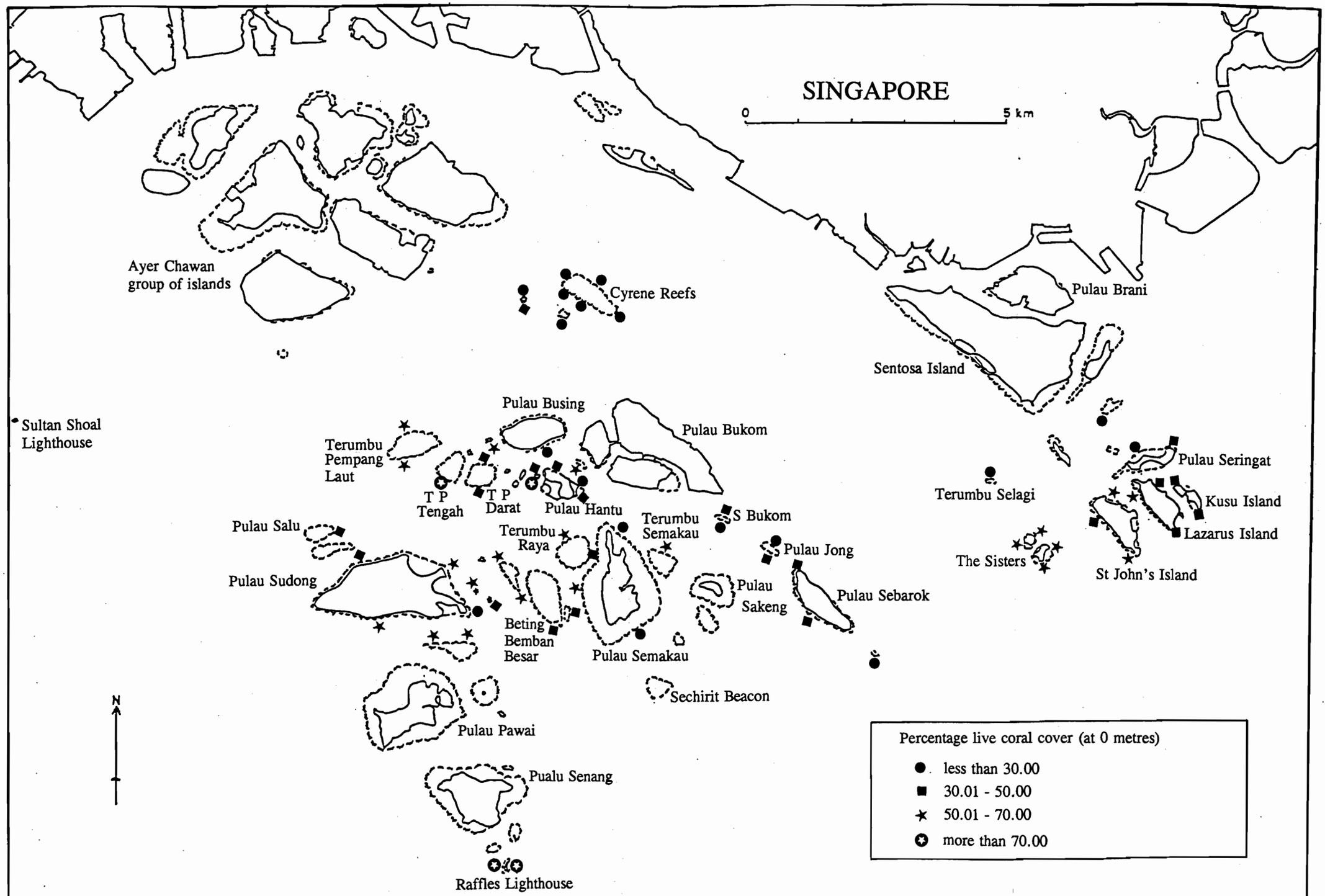


Figure 1. Map of Singapore's southern islands showing conditions of reefs surveyed (based on live coral cover at the reef crest

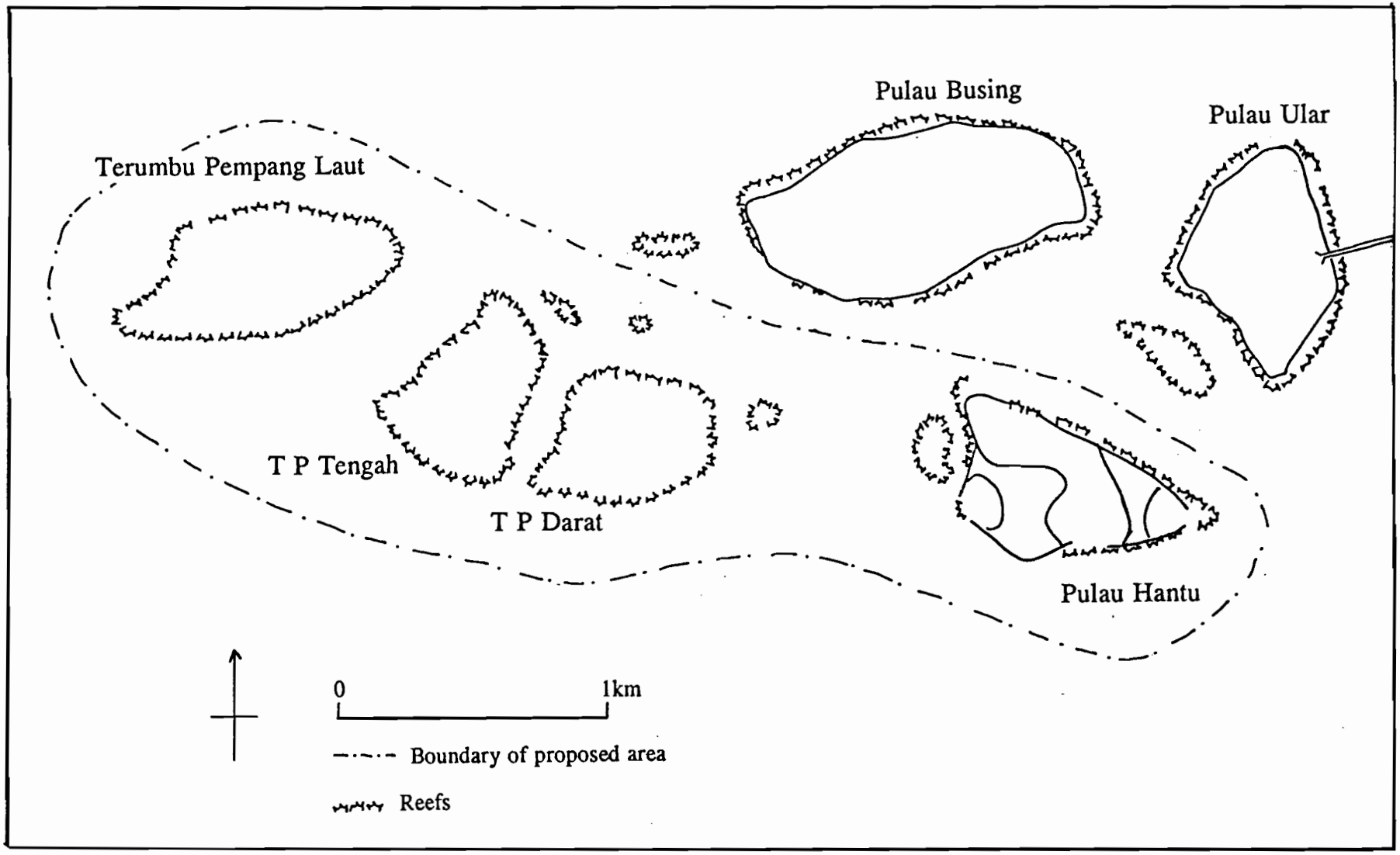


Figure 2a. Area 1

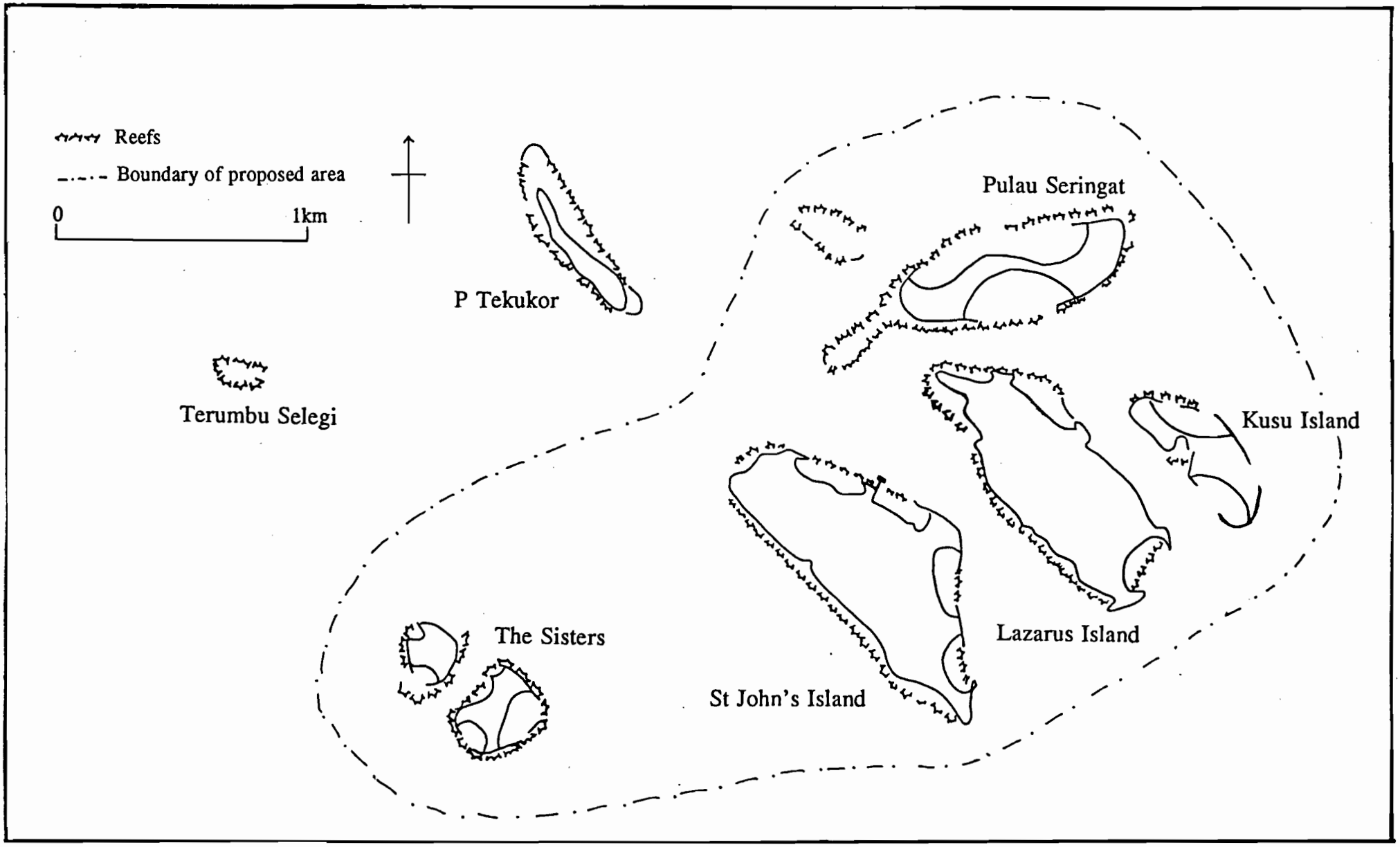


Figure 2b. Area 2

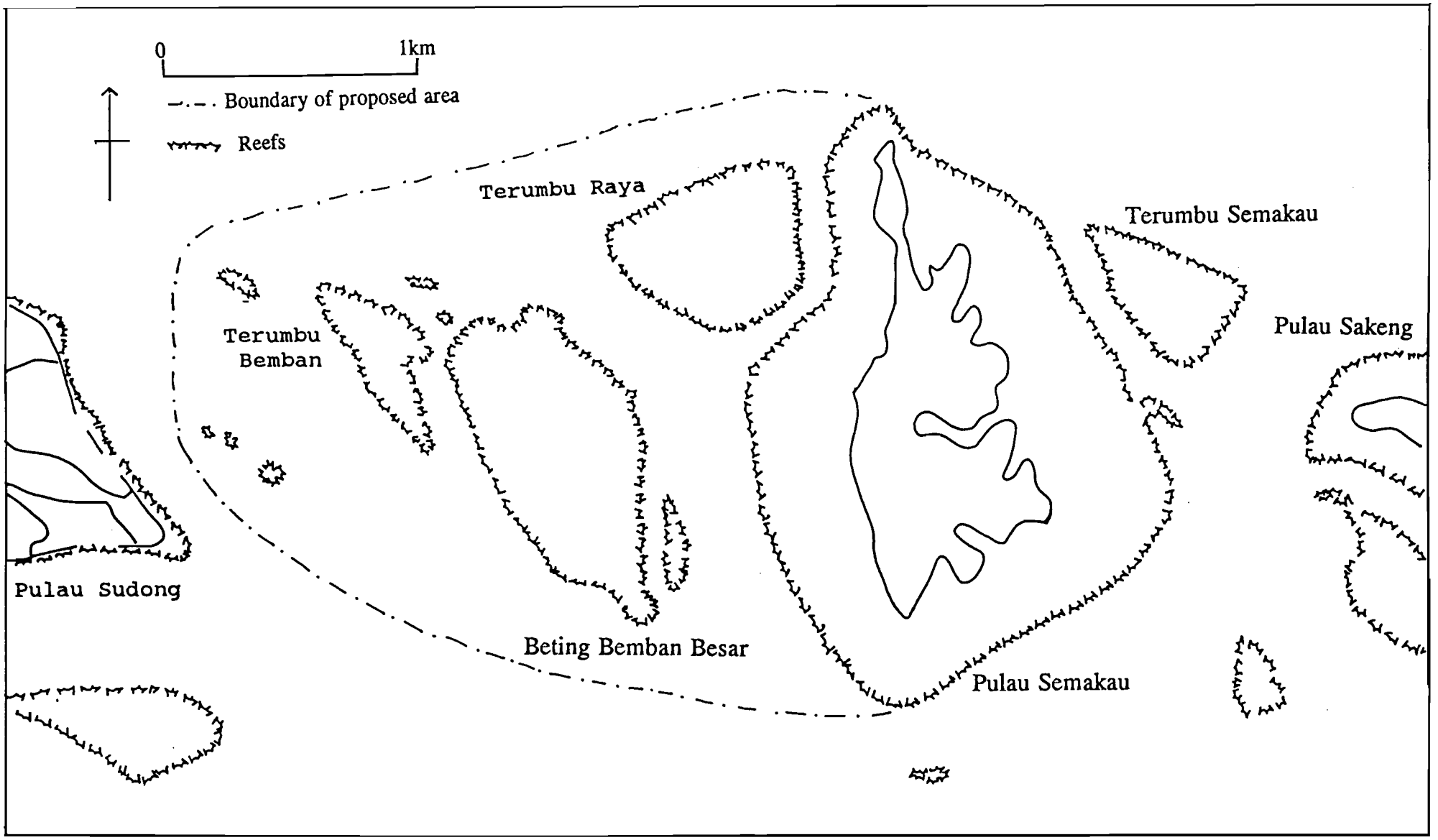


Figure 2c. Area 3

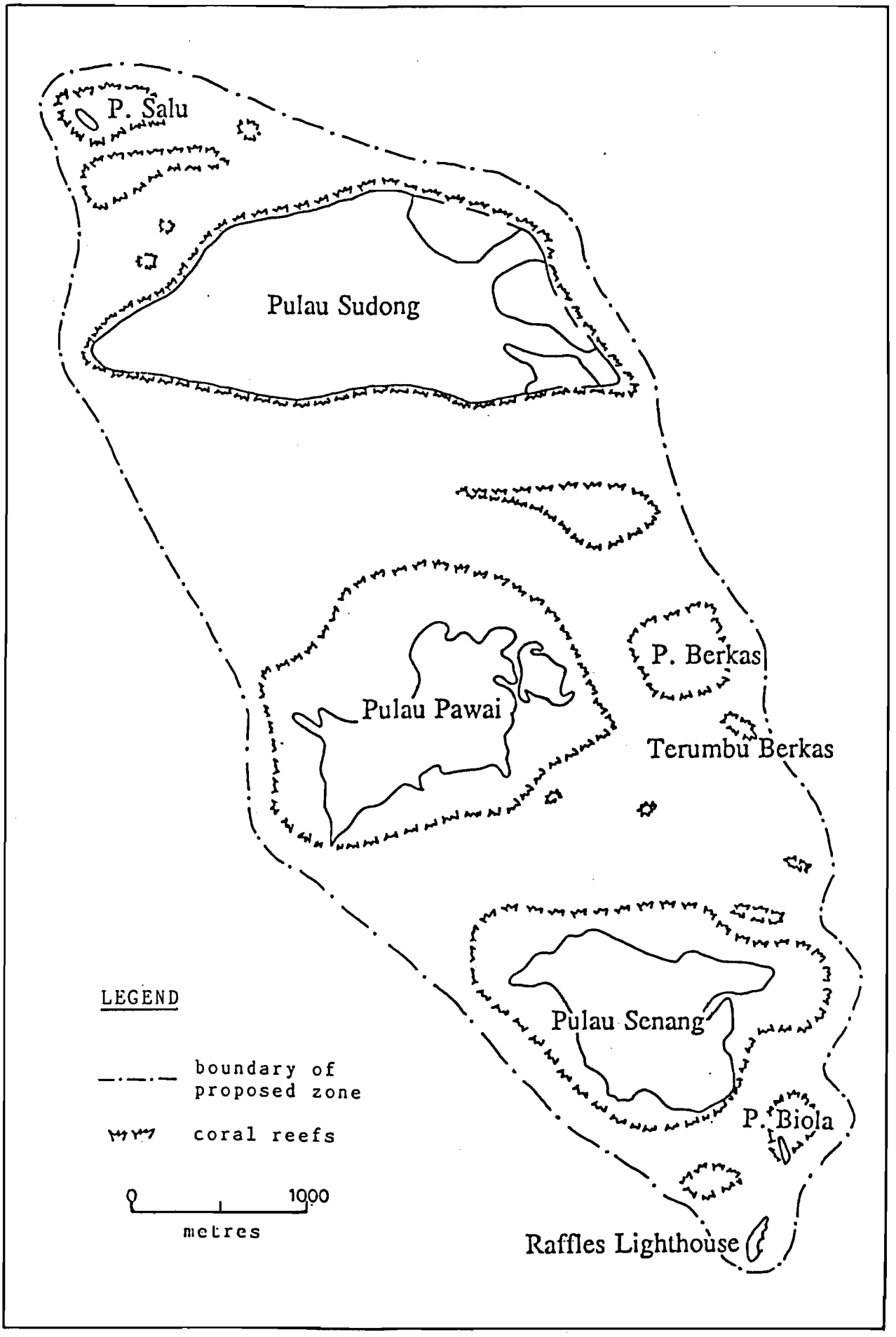


Figure 2d. Area 4

ANNEXES

ANNEX 1. Terms of Reference

I. PREAMBLE

1. Consequent upon meetings between representatives of the Republic of Singapore Yacht Club (RSYC), the Singapore Underwater Federation (SUF), and the Singapore Institute of Biology held in 1987 at the RSYC, it was decided that the Reef Survey & Conservation Project be started jointly by the 3 organisations, with the support of the Singapore Sea Sports Liason Committee (SSSLC).

2. The Project was mooted by the RSYC and was prompted by a shared concern among the representaitves that there has been wanton or unwitting destruction of corals and that there should be better recognition and appreciation of Singapore's reefs and marine life, both by the public and the Government, as part of the natural heritage of Singapore. The representatives would like to see selected reefs conserved for the wholesome recreation of Singaporeans and visitors, the furtherance of scientific research and education, and the enjoyment of future generations.

3. These Terms of Reference have been drawn up to serve as guidelines for the Project and are approved by each of the organisations.

II. NAME

The name of the project shall be the "RSYC-SUF-SIB Reef Survey and Conservation Project" or and derivatives and abbreviations of that name, as may be decided by the Project Committee, hereinafter referred to.

III. PARTICIPATING ORGANISATIONS

1. The Participating Organisations shall be the RSYC, the SUF and the SIB with the support of the SSSLC.

2. In addition thereto, the Project Committee hereinafter referred to, may invite such other organisations as it deems fit to join in, assist or otherwise support the Project, on such terms as it may determine.

IV. OBJECTIVES

1. To identify a reef or reefs in Singapore which may be suitable for survey and conservation.

2. To conduct a detatiled survey of the reef(s) and its marine life.

3. To put up representations to the Government for the preservation of the reef(s).

4. To recommend guidelines for the proper use of and enjoyment of the reef(s), for the benefit of Singaporeans and visitors.

5. To publish the results or utilise the findings in any manner for scientific or recreational purposes, of as may be approved by the Project Committee hereinafter referred to.

V. GENERAL TERMS OF REFERENCE

1. **Duration**

The Project Committee hereinafter referred to, shall subsist so long as any of the Objectives have not been achieved.

It may be dissolved by a decision representing a majority of at least 2 of the 3 original Participating Organisations.

2. **Representation / Project Committee**

Each Participating Organisation shall appoint two represenatives who should preferably include the Commodore, the President, or the Head of the Organisation; of his nominee; of the key person directly involved in the Project.

One of them shall be the Official Representative of the Organisation concerned and the other shall be his Alternate.

The Official Representative or Alternate shall be deemed to have authority to act on behalf of the Organisation he represents.

The Official Representaitves shall constitute a Project Committee, which shall be responsible for the entire project.

3. **Quorum, Decisions, Voting, etc**

A simple majority of the Official Representatives/Alternates representing the Participating Organisations shall constitute a quorum.

All questions arising shall be decided by simple majority.

For this purpose, each Participating Organisations shall have one vote, to be exercised by the Official Representative, or in his absence, his Alternate. Where the Official Representative is present, the Alternate will have no vote.

The Project Committee shall, as far as practicable, endeavour to act by concensus.

4. **Power to co-opt**

The Project Committee may co-opt any one with voice but without vote, onto the Project Committee.

5. **Officers of the Project Committee**

Official Representatives and/or Alternates may appoint or elect from amongst themselves, such officers as may be necessary or helpful for the proper functioning of the Project Committee.

Such Officers should, as far as possible, include a Chairman and 2 Vice Chairmen, each of the 3 of whom should be preferably be from a different Prticipating Organisation; and a Secretary, which can be from any of the Participating Organisations.

6. **Power to Appoint Professional Advisers**

The Project Committee shall be empowered to appoint professional or technical advisers and consultants. As far as possible, such persons appointed should be willing to provide their services without charge in support of the Project. But where charges are necessary, the Project Committee shall ensure that there are available funds to cover the expenses.

7. **Minutes / Notes**

Minutes or notes shall be kept of all meetings and decisions of the Project Committee.

8. **Expenses**

The Project Committee shall attempt to get sponsers to cover the expenses of the Project.

9. **Prohibitions**

The Project Committee shall not organise or register any new society or organisation and shall as far as possible function informally.

10. **Changes to Terms of Reference**

No changes to the Terms of Reference shall be effected unless the prior approval of all Participating Organisations or their Official Representatives/Alternates, have been obtained.

ANNEX 2. List of Project Committee members, 1987-1991

Mr Francis Lee	Chairman	RSYC/SSSLC
Dr Chou Loke Ming	Vice-Chairman	SIBiol
Mr Khoo Soo Seng	Vice-Chairman	SUF/RSYC
Dr Harry Ho / Mr Loo Soon Heng	Vice-Chairman	RSYC
Ms Ang Kai Ling	Hon. Secretary	RSYC
Ms Jocelynna Yap	Asst. Hon. Sec. 1987 - 1989	RSYC
Ms Anne Yeo	Asst. Hon. Sec. 1989 - 1990	RSYC
Dr Khoo Hong Woo	Member	SIBiol
Mr Christopher Chua	Member	SIBiol
Ms Maylene Loo	Member	SIBiol
Mr Tony Chia	Member 1987 - 1988	SUF
Mr Moses Toh	Member	SUF
Mr Peter Loong	Member	SUF
Ms Priscilla Tan	Member	SUF

ANNEX 3a. List of volunteer divers

1 CHEW SZE MUN
2 DESMOND YEE
3 GOMEZ, MANUEL NELSON
4 LIAO MUN LEONG, VICTOR
5 LOIW KWEE GICK
6 MAURICE YUEN
7 ROBERT CHAN
8 TAY YEW CHEE
9 CHIA SER KIAN
10 HSU JUNG CHI, ALFRED
11 LEO TEO WAH, VINCENT
12 LIM BOON CHAI, BILLY
13 PANG TZE MING, JIMMY
14 PARTHIPHAN s/o KRISHNAN
15 SIEW KA MING, DAVID
16 CHUA AIK YONG
17 DANNY LOONG
18 JEFFREY KWIK
19 NG SUET KHUN, BERNICE
20 ONG JOO LAY, JUDY
21 TOH WAH HOCK, MOSES
22 BOEY YEW TUNG
23 CHIA HO BENG
24 GOH WEE GIAM
25 LEE CHENG MAI, JEAN
26 TAN GUAN HONG, STEPHEN
27 TAN SIEW BEE, KELLY
28 WINSON ANG
29 BAET YEOK LING
30 GAN CHENG SIONG
31 KAM LEONG HUAT, MICHAEL
32 NEO SOON TECK
33 NG JUI MENG
34 NG KIM POH
35 TAN LEONG WHATT, PAUL
36 WEE YEOW CHONG, JIMMY
37 CHAN HENG FAI, VINCENT
38 CHEAH KIAN THONG
39 DAVID TING
40 KOH JOO KIM
41 LEE YEE CHUN
42 NG BUCK SENG
43 NG ENG BIN
44 NICHOLAS CHEE
45 HO JOHN CHAN
46 SHARON NEO
47 SIN SIANG MENG
48 NG FUI KHIM
49 CHUA ENG KEE, DAVID
50 KOK WAI KEONG, RICHARD
51 AUDREY CHIA
52 CHAN KWEE FHEN, ALISIA
53 CHIA CHWEE YONG, TONY
54 HAN WAI KWONG, JOHNNY
55 KHOO SOO SENG
56 MARISA SIM
57 MORGAN CHAN
58 TAN SIEW LOU, PRISCILLA
59 TAN YONG HONG
60 YEO LAY CHOO
61 ANG KAI LING
62 FRANCIS LEE
63 SOH KIM POH, PAUL
64 TAN CHENG KWEE, JOSEPH
65 TAN YEW SENG
66 CHONG ERN CHI
67 CHOU LOKE MING
68 CHUA TIEN SHYANG, TIMOTHY
69 CHUA YONG YEOW, CHRISTOPHER
70 GAN WAN SIEW, LYNDON
71 GOH KHENG CHEONG, NIGEL
72 GOH LAY HONG
73 GOH PI LEE, BEVERLY
74 HSU HWEE LUCK, LILIAN
75 KOH GEOK LIANG, ESTHER
76 LEE KEE SENG
77 LENG CHIN BENG
78 LIM SU-YEONG, GRACE
79 LOO GEOK KUAN, MAYLENE
80 LOW KIM YEW, JEFFREY
81 QUEK SWEE TIAG
82 SANJAY A/L C. KUTTAN
83 YIP WAI KUAN

ANNEX 3b List of volunteer divers with less than three surveys

1 WONG LEE CHENG, CLAUDIA
2 BOY MOW CHAN
3 KANG SEOK LAN, AMY
4 PHUA MUI HIAN, ANITA
5 TAN CHENG SOON, PAUL
6 TAN SWEE TIAN
7 TOH HAN NAH
8 WONG HOON NGIAP, ALFRED
9 CHUNG S K MICHAEL
10 JEAN ONG
11 MAHESH KUMAR
12 MICHAEL ONG
13 WEE KIM WEE, MEL
14 WONG CHIN FOH, WILLIAM
15 YONG KOK CHOON
16 CHANG KOK KWONG, BERNARD
17 CHOONG CHOW SIONG
18 KO KHENG LENG, ERIC
19 CHUA PHAIN CHEONG
20 FOONG CHOON POH
21 AMY GOH
22 LER YIAN KHOON, ANDREW
23 LIM SEOW ENG, JENNY
24 TAN SHER KHING, STANLEY
25 BOCK YIN HAR
26 CHEAH KHAM WENG
27 GOH KEE HOCK
28 HSU MOH LEONG
29 TAN CHIN TIONG
30 TAN YONG HONG
31 TAY HUAT HAI
32 YEO SIM TECK, ANNE
33 ANG HUI PENG, WILLIAM
34 CALVIN LAI
35 GWEE CHONG HO
36 KOH HWEE KEOW
37 LIM WEE MING
38 PAULINE LOH
39 PUVENESVERAN, K
40 TAN BENG SWEE
41 TAY CHEK HEONG
42 TEO ZEE VEE
43 JANET TAN
44 TAN CHENG TONG, TONY
45 ESTHER LAI
46 GOH JOON SENG
47 ROBERT JORDAN
48 VICTOR TAN
49 YEUNG KAI HOI
50 STEPHEN SOH
51 LIM CHEE NGUAN
52 MOTT, DAVID B.
53 STEVEN LEK
54 KHOO HONG WOO
55 TAY JOE BOY

ANNEX 4. List of helpers (Non-Project participants)

1. Paul Chua
2. Edward
3. Calvin
4. Michael Chua
5. Sam Toi
6. Tan Beng Hai
7. Vivien Ang
8. Adeline Teo
9. Patrick Ang
10. Teo Joo Howe
11. Ng Tin Fu
12. Sebastian
13. Eunice Han
14. Lawrence Sim
15. Kenneth Lee
16. Ng Cheng Kan
17. Chiam Toh Seng
18. Martin Wong
19. Michael Tan
20. Choong Tet Sang
21. Lim Kim Cho
22. Sim Kwong Hiong
23. Ng Saing Boon
24. Sebastian Ong
25. Michael Han
26. Martin Wong
27. Sheila Cordona
28. Agnes Kwek
29. Koh Tai Beng
30. Jenice Koh
31. Jane Ng Geok Hoo
32. Angeline Teo
33. Ian Waterson
34. Angeline Teo
35. Paul Kwek
36. Bakri Abubakar
37. Anthony Khoo
38. Patricl Soh
39. Peter Tan
40. Wilna Au Bee Koon
41. Roy Sum Kum Wah
42. Panther Poh Wee sen
43. Jenny Tan
44. Gary Lim
45. Ong K.C.
46. Ng Y.S.
47. Ng Cheng Yan
48. Choong
49. Agnes Kw
50. Tan Beng Hai
51. Ng Tin Fu
52. Tay Yew Chee
53. Low Chwee Hock
54. Low Hong San
55. Lim Yong Chin
56. Chate Pattanakue
57. Patrick Tang
58. Chor Meng
59. Paul Tan

ANNEX 5.

Mangroves, Coral Reefs and Seagrasses

Mangroves, coral reefs and seagrasses are among the world's most important – and most endangered – ecosystems. They both nurture the seas and protect the land. They provide vital breeding grounds and habitats for fish, shelter for coasts from the effects of storms, and inhibit erosion. But they have been increasingly under attack for decades, a crisis that has been virtually ignored.

Nearly two thirds of all fish caught throughout the world are hatched in mangrove and tidal areas. Roughly 90 per cent of all commercial species of fish and shellfish taken in the Gulf of Mexico and the Caribbean, for example, depend on mangroves, seagrasses and coral reefs at critical stages in their life cycles. Some 80 per cent of the Indian fish catch from the lower delta region of the Ganges and Brahmaputra rivers comes from the mangrove swamps of the Sundarbans, which cover 6,000 square kilometers.

Mangroves in retreat

Mangrove forests supply important habitats for over 2,000 species of fish, invertebrates and plants. They are at least as productive as good farmland. Some 55 species of salt-tolerant mangrove trees and shrubs cover roughly 240,000 square kilometers of coastal land throughout the world.

Everywhere they are in retreat. Millions of hectares worldwide have been cut down for timber, fuelwood and wood chips, destroyed to create fish and shellfish ponds, or to expand urban areas and agricultural land. They are poisoned by pesticides washed off agricultural fields and smothered by sediment from coastal development, the deforestation of upland watersheds and mining operations.

The worst destruction is taking place in Asia. The mangrove area of the Philippine archipelago was reduced from 5,000 square kilometers to only 380 between 1920 and 1988. Most of it was clear-cut for its valuable timber, exploited for tannin, or converted into fish ponds. More than 2,000 square kilometers of Indonesia's mangrove forests are being exploited for the woodchip industry, producing 250,000 cubic meters a year for export to Japan; another 10,000 square kilometers of Indonesian mangroves have been converted into brackish water ponds in order to cultivate prawns, shrimp and milkfish.

Nearly the entire north coast of Java – once lined with mangroves – is now lined with these ponds, called "tambaks". Here, as in many areas, mangrove destruction has begun a cycle of coastal degradation.

As the mangroves go, fish catches decline and so fishing communities create more tambaks, destroying more mangroves. Often shrimp farms depend on larvae from wild stocks at sea, which disappear as the mangroves are cut down. Within a few years, the ponds have become uneconomic and the whole process is repeated elsewhere.

Mangroves stabilize shorelines; when they disappear their protection is gone and the land is vulnerable to the sea. Both Thailand and the United States specially cultivate mangroves to protect coasts from erosion. They also trap silt washing off the land and filter out pollution.

Coral reefs under attack

Coral reefs are among the oldest and richest living communities of plants and animals on earth. Most coral reefs are between 5,000 and 10,000 years old: many form thin veneers on older, much thicker reef structures several million years old. Most of the reef is dead, but it is covered by a thin, changeable, living skin of coral.

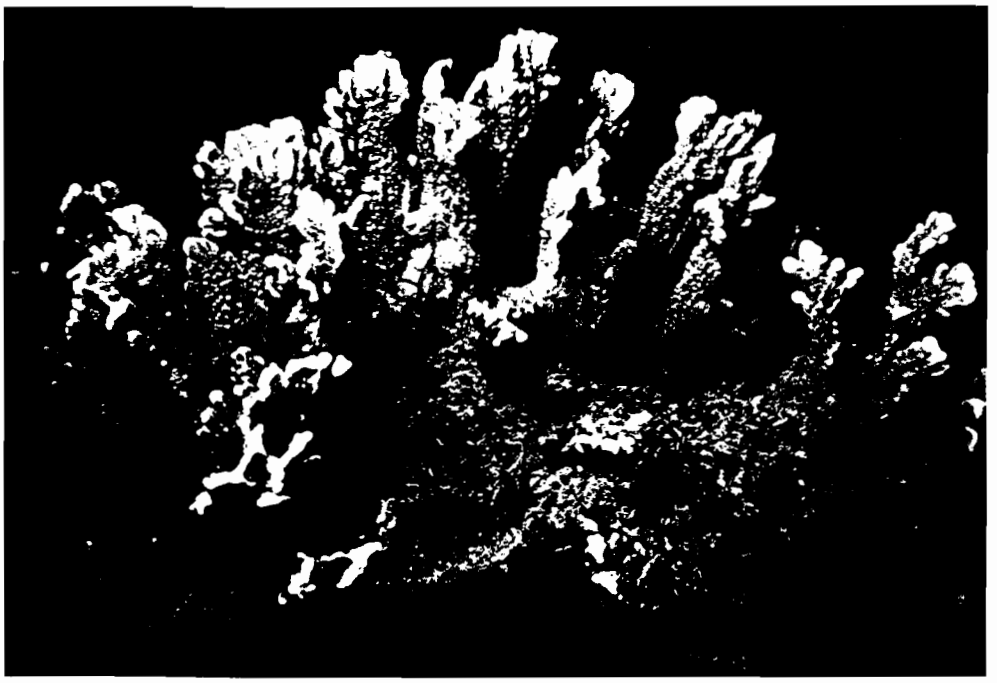
The world's 600,000 square kilometers of coral reefs are as rich in species as its tropical rainforests. A single reef may contain 3,000 species of corals, fish and shellfish. These can yield up valuable medicines: Didemnin, which comes from sea squirts, is active against a broad range of viruses – from colds to herpes and meningitis. Potential anti-cancer drugs are also being found.

Nearly one third of all fish species live on coral reefs, while others are dependent on reefs and seagrass beds at various stages in their life cycles. Although estimates as to the amount of fish that can be harvested from reefs vary, it should be possible to take some 15 metric tons per square kilometer without destroying stocks. Almost 90 per cent of all fish caught by artisanal fishermen in Indonesia depend on coral reefs, as do some 55 per cent of the fish consumed by Filipinos.

The reefs calm the energy of the waves, and protect the shores against storms. When one reef in Sri Lanka was destroyed, the shoreline was pushed back some 300 meters by the unrestrained sea. They also bring tourists: more than half of the GNP of the Bahamas comes from people holidaying on its coasts, and the Great Barrier Reef earns Australia $90 million a year.

Yet coral reefs are being degraded and destroyed at unprecedented rates, throughout the tropics. Of the 109 countries with significant coral communities, 93 are damaging them. In over 50 countries coral is being smothered by silt. As forests are cut down inland, soil washes down the rivers and into the sea; the mangroves that once trapped the silt have often disappeared, so it is carried out to the reef.

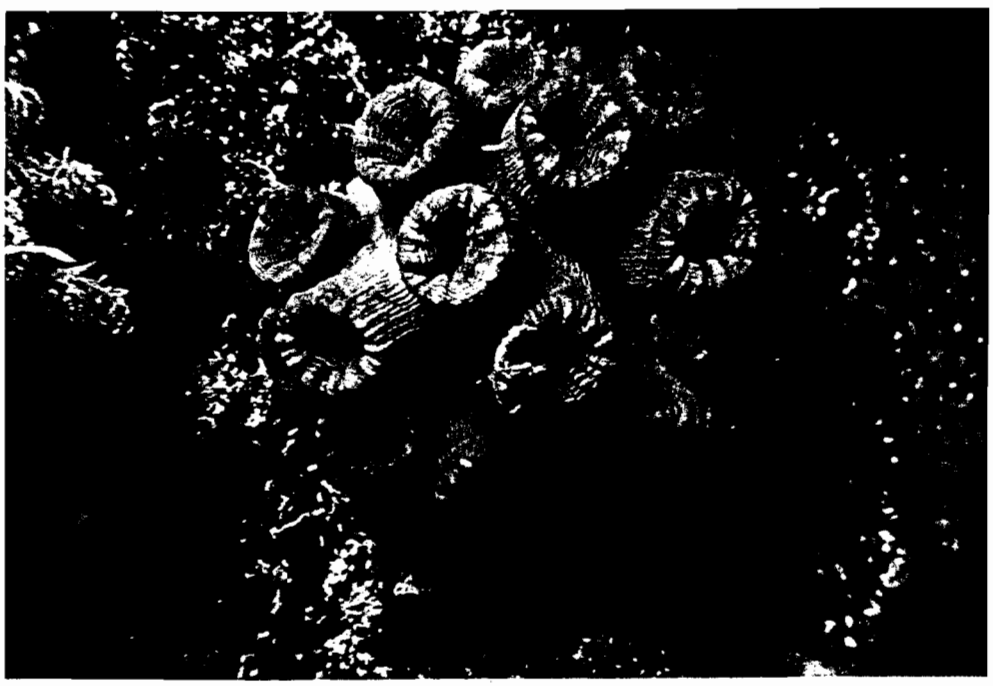
ANNEX 6.



Digitate hard coral, *Montipora*

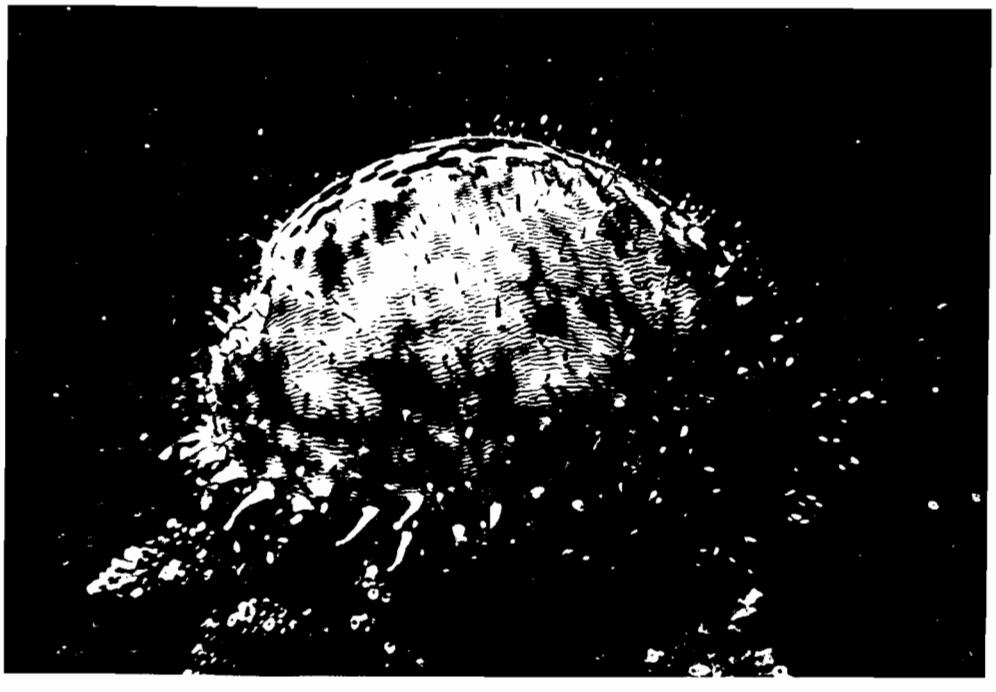
Acropora coral, common only at Raffles Lighthouse reef

The tentacles of this coral resemble anchors



Brightly coloured *Tubastraea*, a coral found in dim light conditions

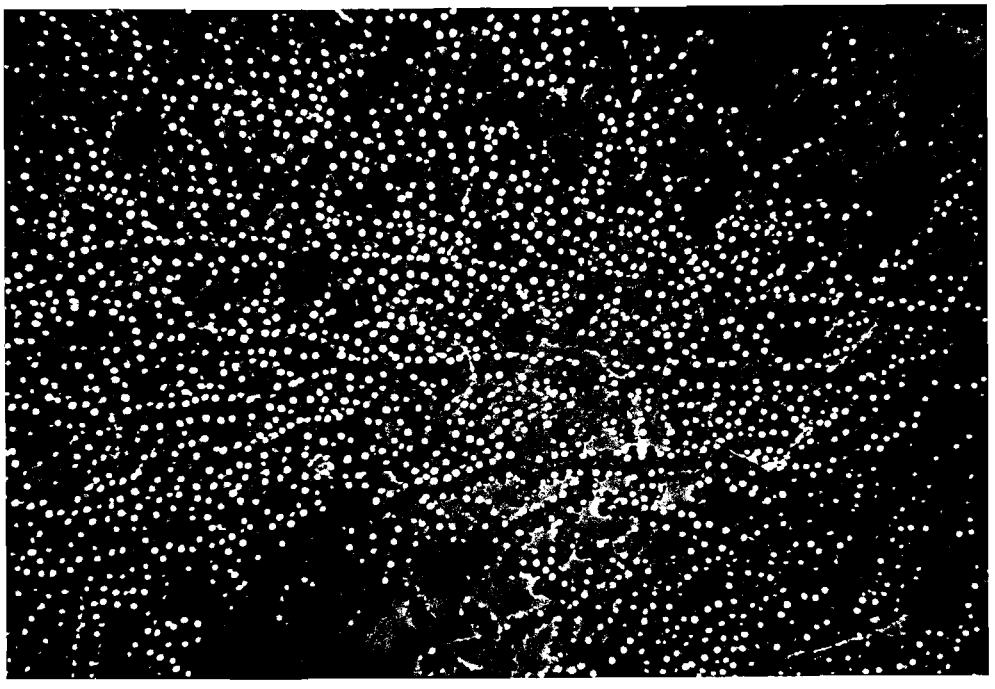
Clown fish sheltering in the protective tentacles
of an anemone



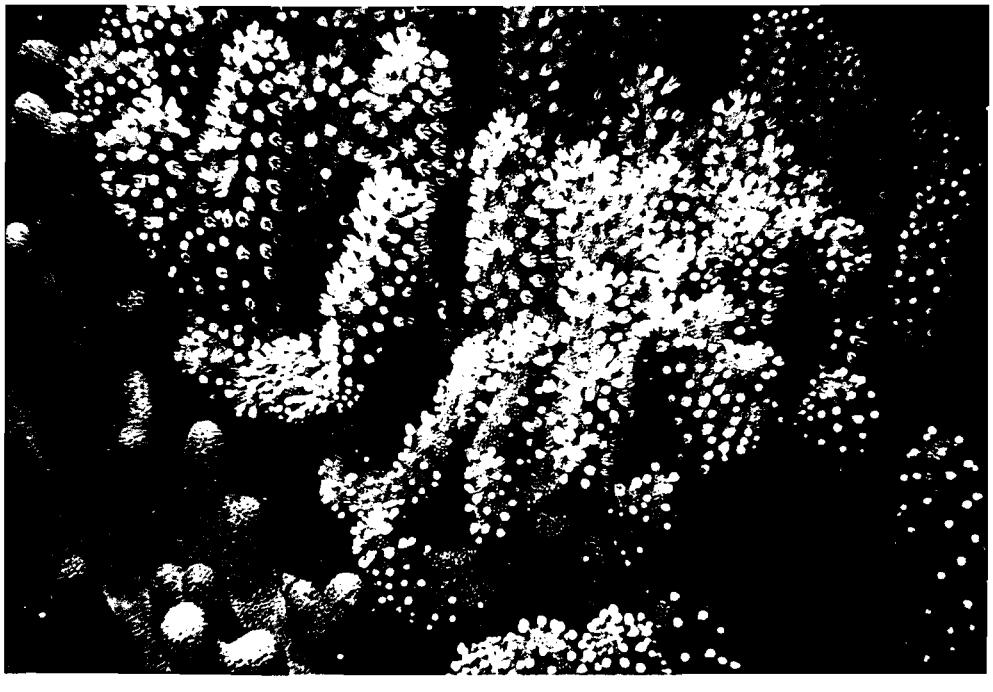
The tiger cowrie - rare but still present on our reefs

A fascinating feather-star

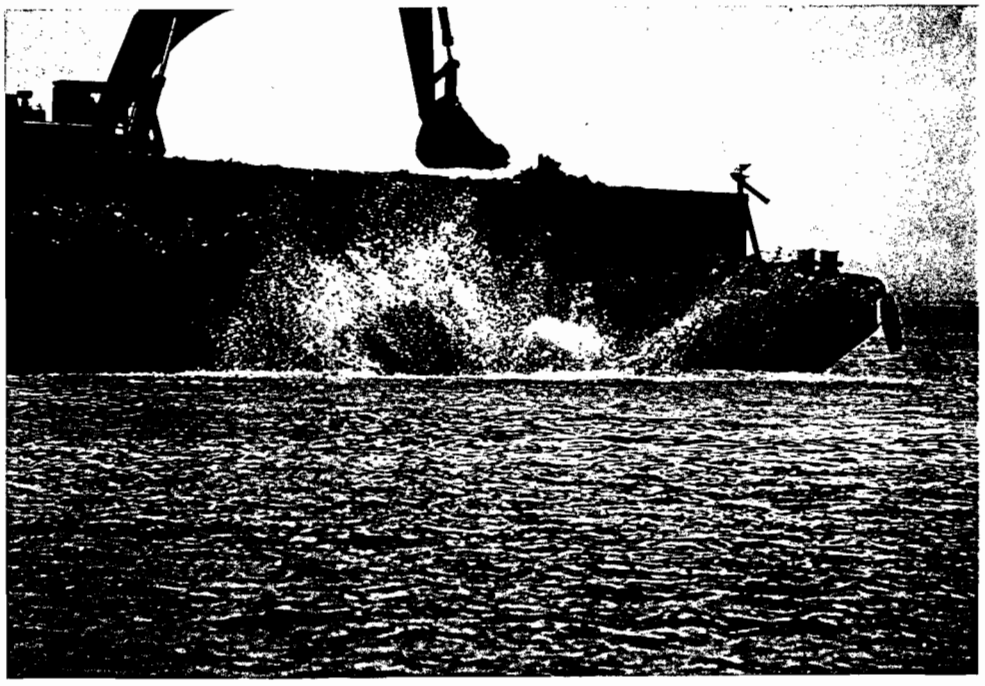
A colony of green-coloured sea squirts



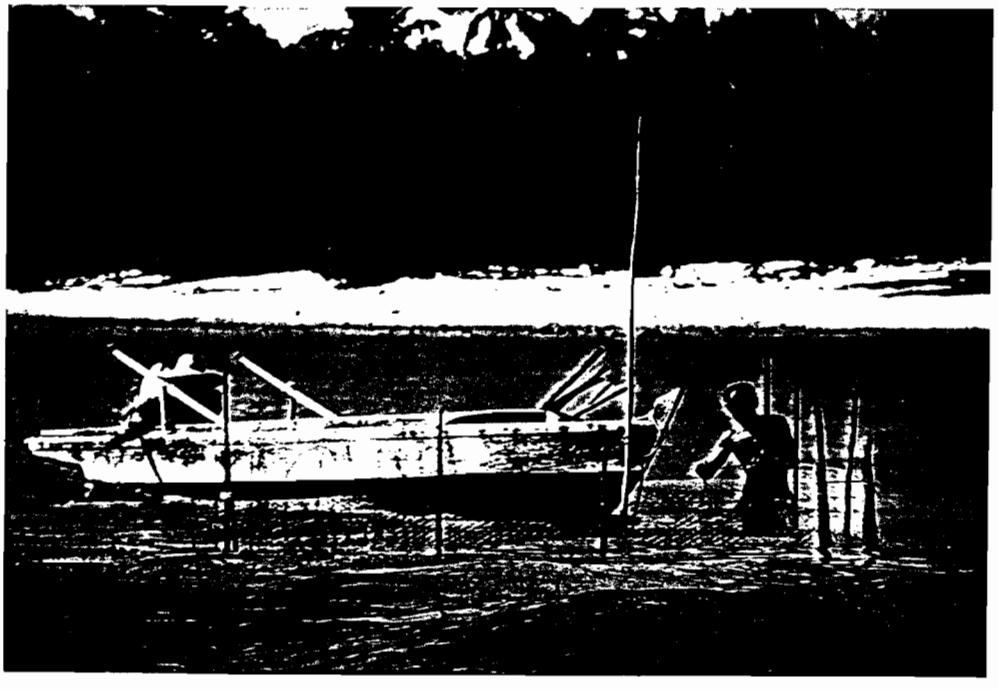
A variety of colourful sea fans grows on our reefs



A colony of soft coral with extended tentacles



Dumping of earth spoils near Pulau Semakau in this manner spreads sediment over wide area



Fishermen building holding corral for trapped fish on reef flat