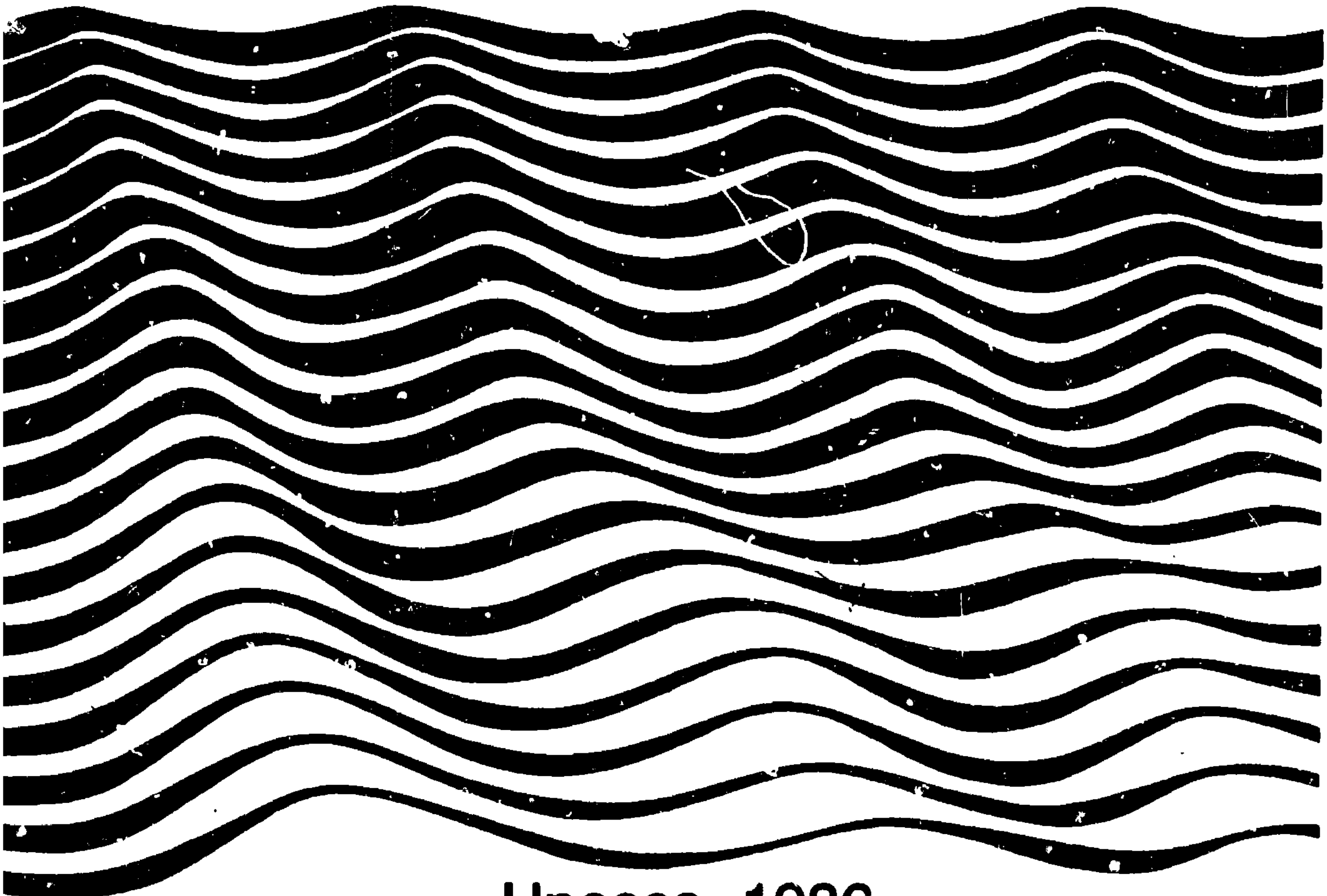
Unesco reports
in marine science 40

Human induced damage to coral reefs

Results of a regional Unesco
(COMAR) workshop
with advanced training

Diponegoro University, Jepara
and National Institute
of Oceanology,
Jakarta, Indonesia, May 1985



Unesco, 1986

UNESCO REPORTS IN MARINE SCIENCE

No.		Year
1	Marine ecosystem modelling in the Eastern Mediterranean Report of a Unesco workshop held in Alexandria, Egypt, December 1974 English only	1977
2	Marine ecosystem modelling in the Mediterranean Report of the Second Unesco Workshop on Marine Ecosystem Modelling English only	1977
4	Syllabus for training marine technicians Report of an IOC/Unesco workshop held in Miami, Florida, 22-26 May 1978 Available in English, French, Russian and Spanish	1979
5	Marine science syllabus for secondary schools Report of an IOC workshop held at United World College of the Atlantic, United Kingdom, 5-9 June 1978 Available in Arabic, English, French, Russian and Spanish	1979
6	Organization of marine biological reference collections in the Mediterranean Arab countries Expert meeting held in Tunis, 20-23 September 1978 Available in Arabic, English and French	1979
8	The mangrove ecosystem: Human uses and management implications Report of a Unesco regional seminar held in Dacca, Bangladesh, December 1978 English only	1979
9	The mangrove ecosystem: scientific aspects and human impact Report of the seminar organized by Unesco at Cali, Colombia, 27 November-1 December 1978 Available in English and Spanish	1979
10	Development of marine science and technology in Africa Working Group of Experts sponsored by ECA and Unesco, Addis Ababa, 5-9 May 1980 Available in English and French	1980
14	Marine science and technology in Africa: present state and future development Synthesis of Unesco/ECA survey missions to African coastal states, 1980 Available in English and French	1981
15	Fishery science teaching at the university level Report of a Unesco/FAO workshop on university curricula in fishery science, Paris, May 1980 Available in Arabic, English, French, Russian and Spanish	1981
16	Marine and coastal processes in the Pacific: ecological aspects of coastal zone management Report of a Unesco seminar held at Motupore Island Research Centre, University of Papua New Guinea, 14-17 July 1980 English only	1981
18	Coral reef management in Asia and the Pacific: some research and training priorities Report of a Unesco workshop held in Manila, Philippines 21-22 May 1981 English only	1982
19	Mareas rojas en el Plancton del Pacífico Oriental Informe del Segundo Taller del Programa de Plancton del Pacífico Oriental, Instituto del Mar, Callao, Perú 19-20 de noviembre de 1981 Spanish only	1982
20	Quantitative analysis and simulation of Mediterranean coastal ecosystems: The Gulf of Naples, a case study Report of a workshop on ecosystem modelling Ischia, Naples, Italy, 28 March to 10 April 1981 Organized by the United Nations, Educational, Scientific and Cultural Organization (Unesco) and the Stazione Zoologica, Naples English only	1983
21	Comparing coral reef survey methods A regional Unesco/UNEP workshop, Phuket Marine Biological Centre, Thailand, December 1982 English only	1983
22	Guidelines for marine biological reference collections Prepared in response to a recommendation by a meeting of experts from the Mediterranean Arab countries Available in English, French and Arabic	1983
23	Coral reefs, seagrass beds and mangroves: their interaction in the coastal zones of the Caribbean Report of a workshop held at West Indies Laboratory, St. Croix, U.S. Virgin Islands, May, 1982 English only	1983
24	Coastal ecosystems of Latin America and the Caribbean The objectives, priorities and activities of Unesco's COMAR project for the Latin America and Caribbean region Caracas, Venezuela, 15-19 November 1982 Available in English and Spanish	1983
25	Ocean engineering teaching at the university level Recommended guidelines from the Unesco/IOC/ECOR workshop on advanced university curricula in ocean engineering and related fields, Paris, October 1982 Available in English, French, Spanish, Russian, Arabic and Chinese	1983
26	Global survey and analysis of post-graduate curricula in ocean engineering English only	1984
27	Productivity and processes in island marine ecosystems. Recommendations and scientific papers from the Unesco/IOC sessions on marine science co-operation in the Pacific, at the XVth Pacific Science Congress, Dunedin, New Zealand, February 1983 English only	1984
28	Oceanographic modelling of the Kuwait Action Plan (KAP) Region. Report of simposium/workshop; University of Petroleum and Minerals, Dhahran, Kingdom of Saudi Arabia 15-18 October 1983 English only	1984
29	Eutrophication in coastal marine areas and lagoons: a case study of 'Lac de Tunis' Report prepared by Dr M. Kelly and Dr M. Naguib English only	1984
30	Physical oceanography of the Eastern Mediterranean: an overview and research plan Report of a workshop held in Lerici, La Spezia (Italy), September 1983 English only	1984
31	MABAHISS/John Murray 50th anniversary: Marine science of the North West Indian Ocean and adjacent waters Report of a symposium on the occasion of the 50th anniversary of the MABAHISS/John Murray Expedition (1933/34), University of Alexandria, Egypt, 3 to 7 September 1983 English only	1985
32	L'estuaire et la mangrove du Sine Saloum Résultats d'un Atelier régional Unesco-COMAR tenu à Dakar (Sénégal) du 28 février au 5 mars 1983 French only	1985
33	Coral taxonomy Results and recommendations of a regional Unesco (COMAR)/UNEP Workshop with advanced training Phuket Marine Biological Centre Thailand, 10-26 February 1984 English only	1985
34	Bibliography on costal lagoons and salt marshes along the Southern Mediterranean coast (Algeria, Egypt, Libya, Morocco, Tunisia) Available in Arabic, English and French	1985
35	Physical oceanography of the Eastern Mediterranean (POEM): A Research Programme. Reports of the Organizing Committee Meeting, Paris, August 1984, and the Scientific Workshop, Lucerne, October 1984 English only	1985
36	Méthodologie d'étude des lagunes côtières. Résultats d'un atelier régional réuni à Abidjan du 6 au 11 mai 1985 French only	1986

Cont'd on inside of back cover

Unesco reports in marine science 40

Human induced damage to coral reefs

Results of a regional Unesco (COMAR) workshop with advanced training

Diponegoro University, Jepara and National Institute of Oceanology, Jakarta, Indonesia, May 1985

Edited by:
Dr Barbara E. Brown

Sponsored by:
Unesco-Coastal Marine Project (COMAR)
Unesco-ROSTSEA
Laboratory for Coastal Zone Ecodevelopment
Diponegoro University, Jepara, Indonesia
National Institute of Oceanology, Jakarta, Indonesia

comar

40e ANNIVERSAIRE
1946 1986
40th ANNIVERSARY

Unesco, 1986

ISSN 0253-0112

Published in 1986
by the United Nations Educational,
Scientific and Cultural Organization,
7, place de Fontenoy, 75700 Paris.
Printed in Unesco's workshops.

PREFACE

Unesco Reports in Marine Science are designed to serve specific programme needs and to report on developments in projects conducted by the Unesco Division of Marine Sciences, including those involving collaboration between the Division and the Intergovernmental Oceanographic Commission.

Designed to serve as a complement to the Unesco Technical Papers in Marine Science, the Reports are distributed automatically to various institutions and governmental authorities. Individuals may, at their request, receive copies of specific titles, but cannot be included on the automatic distribution list. Both the Reports and the Technical Papers series are free of charge.

Requests for copies of specific titles or for additions of institutions or authorities to the mailing list should be addressed, on letterhead stationery if possible, to:

Marine Information Centre
Division of Marine Sciences
Unesco
Place de Fontenoy
75700 Paris
France

ABSTRACT

This report summarises work undertaken in the Bay of Jakarta and Thousand Islands by participants from all over South East Asia, during a Unesco Workshop in 1985. Over 550 manhours were spent collecting data on the geomorphology of islands mapped first by the Netherlands in the early 1900's; on the biological status of the surrounding coral reefs and measurements of coral growth along a pollution gradient from Jakarta Bay to the outermost Thousand Islands, some 80 km from the capital.

During the Workshop over thirty islands were visited and surveyed. The results of the exercise showed that many of the reefs had deteriorated in condition since the earlier studies and that some of the islands in Jakarta Bay had almost disappeared as a consequence of erosion resulting from dredging of the reefs nearby.

The report also contains sections on methods for assessment of reef deterioration and their application in the field as well as statements on human induced damage to reefs in the Philippines, Indonesia, Thailand, South China Sea, Maldives and Papua New Guinea.

RESUME

Le présent rapport résume les travaux effectués dans la baie de Djakarta et des Kepulanan Seribu (mille îles) par les chercheurs de toute l'Asie du Sud-Est qui ont participé en 1985 à un atelier de l'Unesco. Plus de 550 heures/homme ont été consacrées à la collecte de données sur la géomorphologie des îles, dont les premières cartes avaient été établies par les Hollandais dans les premières années du siècle, et sur l'état biologique des récifs de corail environnants ainsi qu'à des mesures de la croissance corallienne le long d'un gradient de pollution s'étendant de la baie de Djakarta aux plus éloignées des îles, à quelque 80 kilomètres de la capitale.

Dans le cadre de cet atelier, plus de 30 îles ont été inspectées et on fait l'objet de levés. Il ressort de ces travaux que l'état de nombreux récifs s'est dégradé depuis les études précédentes et que certaines des îles de la baie de Djakarta ont presque disparu sous l'effet de l'érosion provoquée par le dragage des récifs proches.

Le rapport contient également des sections qui ont trait aux méthodes d'évaluation de la dégradation des récifs et à leur application sur le terrain, ainsi que des exposés sur les dommages causés par l'homme aux récifs des Philippines, de l'Indonésie, de la Thaïlande, de la mer de Chine méridionale, des Maldives et de la Papouasie-Nouvelle-Guinée.

RESUMEN ANALITICO

En este informe se resumen las actividades emprendidas en 1985 en la Bahía de Yakarta y en las Mil Islas por los participantes en una reunión de trabajo de la Unesco provenientes de toda la región de Asia Sud-oriental. Durante más de 550 horas/hombre se procedió a acopiar datos sobre la geomorfología de las islas, que a principios de este siglo habían sido exploradas con fines cartográficos por cartógrafos neerlandeses, a examinar las condiciones biológicas de los arrecifes de coral y a medir el crecimiento del coral a lo largo de un gradiente de contaminación desde la Bahía de Yakarta hasta la más remota de las Mil Islas, a unos 80 km. de la capital.

En el curso de la reunión de trabajo se visitaron y examinaron más de treinta islas. Se pudo comprobar que las condiciones de los arrecifes se habían deteriorado con respecto a lo observado en estudios anteriores y que algunas de las islas de la Bahía de Yakarta casi habían desaparecido como consecuencia de la erosión producida por el dragado de los arrecifes próximos.

El informe contiene, además, secciones dedicadas a los métodos de evaluación de la degradación de los arrecifes y su aplicación <u>in situ</u>, así como a la observación de los deterioros provocados por el hombre en las Filipinas, Indonesia, Tailandia, el Mar Meridional de la China, las Maldivas y Papua-Nueva Guinea.

РЕЗЮМЕ

В настоящем докладе обобщается работа, проведенная в бухте Джакарта и на островах Серибу участниками из всех Юго-Восточной Азии во время учебно-практического семинара ЮНЕСКО в 1985 г. Было затрачено более 550 человеко/часов на сбор данных по геоморфологии островов, впервые нанесенных на карту Нидерландами в начале 1990-х годов, по биологической обстановке на окружающих их коралловых рифах и измерениям роста кораллов наряду с градиентом загрязнения от бухты Джакарта до наиболее отдаленных участков островов Серибу, находящихся на расстоянии около 80 км от столицы.

Во время учебно-практического семинара было посещено и обследовано более 30 островов. Результаты этого мероприятия показали, что состояние многих рифов ухудшилось со времени предыдущих исследований и что некоторые острова в бухте Джакарта почти исчезли вследствие эрозии, вызванной дноуглубительными работами в районе близлежащих рифов.

В докладе также содержатся разделы, посвященные методам оценки разрушения рифов и применения этих методов в экспедиционных условиях, а также сведения о вызванных человеком разрушениях рифов на Филиппинах, в Индонезии, Таиланде, Южно-Китайском море, на Мальдивских островах и в Папуа-Новой Гвинее.

خلاصة

يلخص هذا التقرير الأعمال التي اضطلع بها في خليج جاكارتا والألف جزيرة ، خبراء من كافة أنحاء جنوب شرقي آسيا أثناء حلقة عمل نظمتها اليونسكو عام ١٩٨٥ . وقد أنفق ما يربو عن ٥٥٠ رجل / ساعة في جمع البيانات عن جيومورفولوجيا الجزر التي أعدت هولندا خرائطها في البداية منذ مطلع القرن العشرين ، وعن الوضع البيولوجي للشعب المرجانية المحيطة وقياسات نمو المرجان على امتداد مسار التلوث من خليج جاكارتا الى أقصى الجزر الألف ، أي نحو ٨٠ كيلومترا من العاصمة .

وتمت خلال حلقة العمل زيارة نحو ثلاثين جزيرة وأجريت عليها دراسات . وأظهرت نتائج هذه الدراسات أن العديد من الشعب المرجانية قد تدهورت حالتها منذ الدراسات الأولى وأن بعض الجزر بخليج جاكارتا اختفت أو تكاد نتيجة للتحات الناجم عن انتشال الشعب المجاورة لها .

ويتضمن التقرير أيضا أجزاء تتعلق بأساليب تقدير التلف الذي يصيب الشعب وتطبيقها في هذا المجال ، وكذلك بيانات عن الأضرار التي يسببها الانسان للشعب في كل من الفلبين واندونيسيا وتايلاند وبحر جنوب الصين والمالديف وبابوا غينيا الجديدة .

摘　　要

这份报告总结了１９８５年举行的一期教科文组织讲习班期间来自整个东南亚地区的与会者在雅加达湾和千岛群岛所进行的工作。在收集最早由荷兰于十九世纪初期在地图上标出的一些岛屿的地形学资料，及有关周围珊瑚礁的生物状态和测定沿着从雅加达湾直至远离首都大约８０公里的千岛群岛的外缘这一污染梯度的珊瑚生长情况的资料方面，花费了５５０多个工时。

在讲习班举行期间，考察了３０多个岛屿。考察活动的结果表明，自先前的调查以来许多珊瑚礁的情况已经恶化，此外由于疏浚附近礁石所引起的侵蚀的后果，雅加达湾的一些岛屿几乎已经消失。

报告还包括若干专节述及确定礁石退化情况的方法及其在实地的应用，以及一些有关人为的原因对菲律宾、印度尼西亚、泰国、南中国海、马尔代夫及巴布亚新几内亚的一些珊瑚礁造成的损害的叙述。

TABLE OF CONTENTS

	TITLE	PAGE
INTRODUCTION		1
ACKNOWLEDGEMENTS		2
CHAPTER 1	Background to reef damage in South East Asian Waters and bordering Indo-Pacific Regions.	3
CHAPTER 2	Measuring growth rates of reef corals as an indication of the effects of pollution and environmental disturbance.	12
CHAPTER 3	Environmental assessment and analysis in relation to coastal zone management.	25
CHAPTER 4	Background to the fieldsite at Bandengan Jepara, North Java.	38
CHAPTER 5	Projects on 'assessing change on coral reefs'.	49
CHAPTER 6	Background to the study sites in the Bay of Jakarta and Kepulauan Seribu.	56
CHAPTER 7	Umbgrove's islands revisited.	80
CHAPTER 8	Studies in the assessment of coral reef ecosystems.	99
CHAPTER 9	Distribution, diversity and abundance of reef corals in Jakarta Bay and Kepulauan Seribu.	112
CHAPTER 10	Banding in coral skeletons from Pulau Seribu as revealed by X-rays and UV light analysis.	126
CHAPTER 11	Distribution of reef fish along transects in Bay of Jakarta and Kepulauan Seribu.	135
CHAPTER 12	Man made flotsam on the strandlines of the Thousand Islands (Kepulauan Seribu) Jakarta, Java.	137
CHAPTER 13	Responses of coral reef communities to environmental variables in the Pulau Seribu island chain.	164
SUMMARY		172
APPENDICES	Names and addresses of advisors and participants attending workshop.	174

INTRODUCTION

Indonesia has an extensive coastline of 81,000 km which encompasses over 13,700 islands. Recent population statistics suggest an estimated population of over 142 million, most of whom are concentrated on the island of Java. The coastal resources of Java are, therefore, under considerable pressure. Nowhere is this clearer than in the waters of the Java Sea, close to the nation's capital Jakarta, and also along the north Java coast.

In both regions the coral reef is subject to exploitation for the fish which it supports and also for the corals themselves which are a valuable construction material. Such exploitation and the environmental damage which arises as a result, are common features of most South East Asian countries and so it was appropriate that Indonesia was chosen as the focus for a workshop on human induced damage to coral reefs.

Background to the workshop

The setting of the islands in the Bay of Jakarta and the Kepulauan Seribu, which extend some 80 km north of Jakarta, provided a series of coral reefs ranging from those living in the polluted waters of Jakarta Bay to those in the clearer waters of the Java Sea. The reefs surrounding these islands, moreover, had been extensively studied (particularly those in Jakarta Bay) in the early 1900's by Dutch workers, so providing a useful background for the present study.

Prior to the workshop, Dr Robin Harger of ROSTSEA, UNESCO and Dr Sukarno, of the National Institute of Oceanology engaged in a preliminary survey of a selection of reefs in the Bay of Jakarta and the southernmost Kepulauan Seribu. The results of their survey clearly indicated that many of the reefs had deteriorated in condition since the earlier studies of Dutch workers.

Workshop Format

The aim of the workshop was to train participants in the assessment of human induced damage on coral reefs and islands in the chain, using standard methods of mapping and surveillance of both terrestrial and underwater habitats. In addition specific techniques for measuring the 'condition' of reef corals at different sites were also employed. These included measurement of growth rate of massive corals, through the interpretation of X ray densitometry, fluorescence banding and alizarin staining of coral skeletons.

The workshop was divided into three sections. The first section which involved formal lectures on methodology and practical exercises in the laboratory and field, as well as data assessment was held from May 1-5th 1985 at the University of Diponegoro's field station in Jepara, North Java.

The second section which involved surveillance of over 30 islands and reefs in the Bay of Jakarta and Kepulauan Seribu took place between May 6-16th and was field based at Bidadari (in the bay of Jakarta); Pulau Pari (southern most of the Kepulauan Seribu) and Pulau Sepak (at the northern end of the Kepulauan Seribu).

The third section between May 16-23rd was based at the National Institute of Oceanology in Jakarta. During this final phase participants were introduced to the use of microcomputers for analysis of data collected during the field surveys.

Acknowledgements

The Editor would like to thank Professor Moeljono, Professor Sapardi and the late Professor Gatot and the staff of the University of Diponegoro for their support and generousity in hosting the first section of the workshop; also Dr Aprilani, Dr Sukarno and the staff of the National Institute of Oceanology for their efficient co-ordination of the fieldwork in the Kepulauan Seribu and for hosting the final section of the workshop at their Institute. Finally, my thanks to Unesco for sponsoring the workshop and Dr Robin Harger for his enthusiastic support throughout.

Unesco particularly thanks the late Professor Gatot, the former Director of the Diponegoro University Marine Station at Jepara, who passed away on 06/02/1986, for his tireless enthusiasm in attending to all the details of organization that were necessary to ensure successful implementation of the first stage of the activity.

Notes

CHAPTER ONE

BACKGROUND TO REEF DAMAGE IN SOUTH EAST ASIAN WATERS AND BORDERING INDO-PACIFIC REGIONS

This chapter is a compilation of participant's contributions, on the status of reefs in their own countries, which were presented during the workshop. The geographical range of participants home countries was considerable (Figure 1.1) spanning the Indian Ocean to the west (Maldives) across to the Pacific in the East (Papua New Guinea) and north from Korea and the south China Sea to Indonesia in the south.

It appears that reefs in the whole area were subject to many similar forms of damage, though the degree and extent of man-made interference varied considerably between countries.

i) China

Coral reefs are found in the South China Sea where they may be categorised into two major types, fringing reefs (such as those around Hainai Island) and atolls (e.g. Xisa Islands). About 200 coral species have been recorded from these reefs.

Problems facing coral reefs in the South China sea arise from two sources: firstly, the use of corals in construction industries and secondly, the sale of living corals for the aquarium trade. No figures are currently available for the extent of reef damage but over 110 coral species were recorded at Hainai Island in the 1960s whereas only 20 coral species can be recorded now. The situation in the Xisa Islands is not as serious as that at Hainai Island but an escalating coral trade and overfishing are beginning to cause problems at this location too.

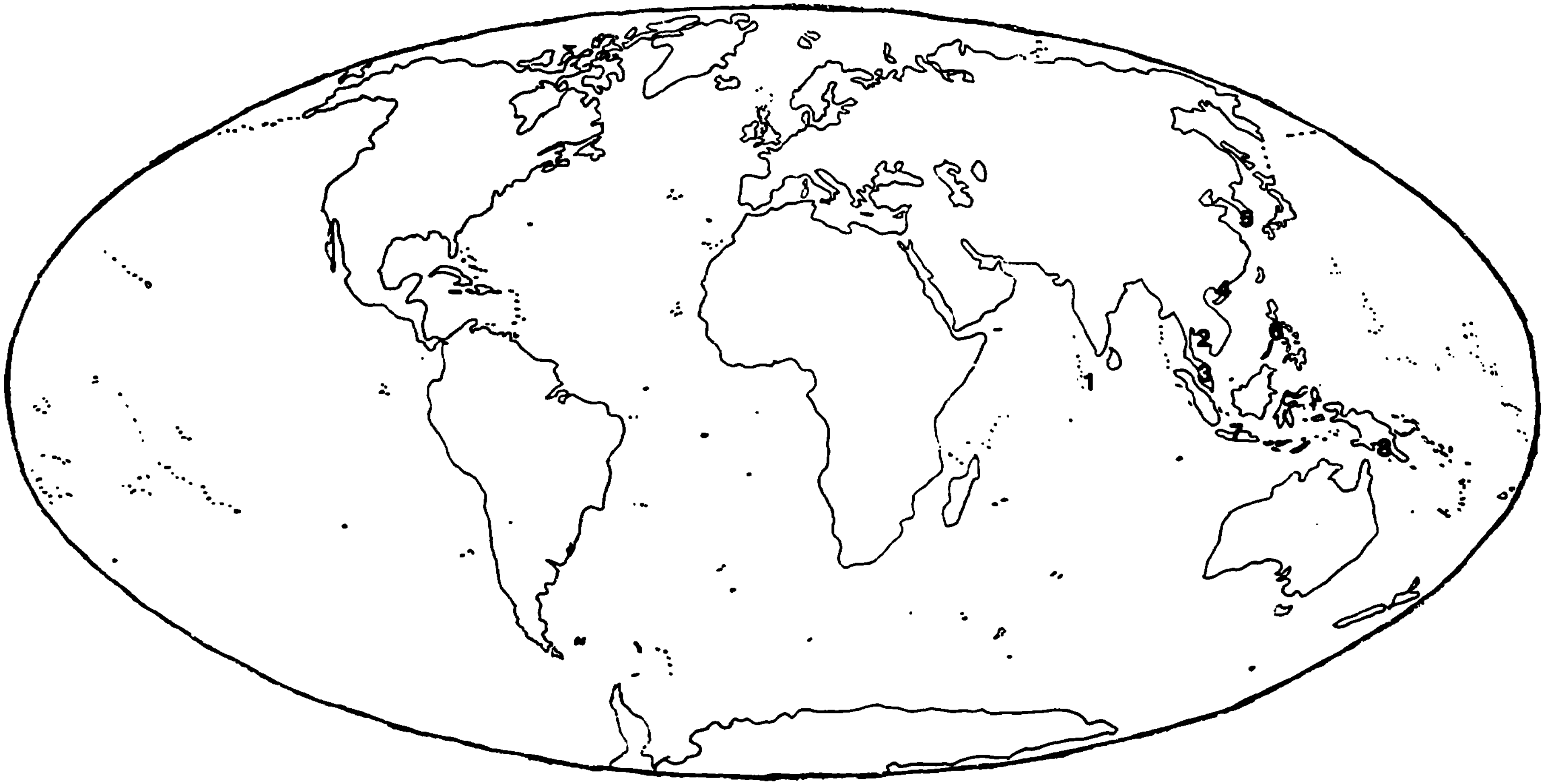
ii) Indonesia

With a coastline of 81,000km and 13,700 islands, Indonesia supports a diverse array of reef types (fringing, barrier and atoll) as well as highly diverse coral assemblages. The eastern islands are situated within the Indo-Pacific high diversity focus where over 80 coral genera have been recorded.

The forms of damage encountered on Indonesia reefs are summarised in Table I.1. It is clear from the Table that a wide variety of potentially deleterious activities are taking place on reefs throughout Indonesia. Theoretically, legislation to cover certain fisheries activities has been in force since 1912 when an act was made prohibiting the use of certain methods of collection of pearl oysters and sponges. Licenses were issued to pearl oyster fishermen and separate regions were designated for traditional pearl oyster divers and those who collected using similar apparatus.

Licences have also more recently been issued to ornamental fish collectors, and exporters must have a five year permit from the Director General of Fisheries. Although the catch limit is not restricted, the limited number of licences available is intended to reduce fishing effort. In addition, the use of damaging fishing techniques (e.g. poisons and explosives) are banned. Two recent acts (Forestry Act of 1967 and an Environmental Management Act of 1982) aim to further conserve selected marine habitats in Indonesia. There are now seven protected

FIGURE 1.1 MAP SHOWING THE COUNTRIES REPRESENTED AT THE UNESCO WORKSHOP AND FOR WHICH REPORTS WERE RECEIVED ON REEF DAMAGE.



1. Republic of the Maldives
2. Thailand
3. Malaysia
4. China
5. South Korea
6. Philippines
7. Indonesia
8. Papua New Guinea

TABLE I.1 Sources and locations of coral damage throughout Indonesia

PROBLEM	LOCATION	REMARKS
(a) BLASTING OF CORAL	East Indonesia (Spermonde Maluku) Kepulauan Seribu	
(b) POISONING OF REEF FISH	Kepulauan Seribu, Bali East Indonesia (Spermonde)	
(c) FISHING		
(i) BUBU TRAP	Found at many sites throughout Indonesia	one type of trap is disguised by a covering of coral
(ii) MUROAMI TRAP	Kepulauan Seribu Madura	
(iii) SPEARING	Kepulauan Seribu Bali	
(d) TOURISM		
(i) COLLECTION OF CORAL & SHELLS & AQUARIUM FISH	Pangandaran, Lampung, Bali, Bandegan, Pasir putih	
(ii) BOAT ANCHOR DAMAGE	Bali Kepulauan Seribu	
(iii) REEF WALKING	Kepulauan Seribu, Bali	
(e) CORAL MINING CONSTRUCTION INDUSTRIES	Bali, Carita, Seram, Kepulauan Seribu Karimum Jawa, East Indonesia, Maluku	
(f) TRIDACNA MINING	Kepulauan Seribu Karimum Jawa	
(g) POLLUTION		
(i) SEWAGE	Jakarta, Bintang	
(ii) THERMAL EFFLUENT	Surabaya, Bintang	Waste waters reported to give seawater T° of 35-40°C.
(iii) OIL EXPLORATION	Kepulauan Seribu	
(iv) SEDIMENTAITON FROM AGRICULTURAL RUN OFF	Carita, Bandengan	
(v) DREDGING FOR MINERALS, e.g. TIN	Bilitung, Bangka Lingga, Sinkep	Billiton now using one of their largest dredges in this area - capacity 12,000 tons.
(vi) DREDGING CHANNELS	Bintang	The area of dredging and reclamation is 3 million m^3.

marine areas in Indonesia (Table I.2); all of which are small and have little management. A further 225 sites have been proposed for protection in the next five year development plan (1982-1987), which will cover 3% of Indonesian waters (Table I.3).

Despite the aforementioned legislation and ambitious conservation plans, Indonesia is faced with an enormous man-power problem both in terms of enforcement of legislation and also in preparation of management proposals. There are simply not enough trained scientists to carry out the surveillance, policing and management of protected areas.

iii) Maldives The Republic of the Maldives consists of 1190 islands grouped into 19 administrative atolls, situated about 400 miles to the south-west of Sri-Lanka in the Indian ocean. The importance of coral reefs to this small island nation is evident in that each of the islands has a reef surrounding it and there are many more submerged reefs within the territorial waters of the country.

Human activities on these coral reefs can be outlined as follows:

(a) Coral and sand extraction. Until very recently lime, coral and sand were the main building materials used in the country. Although lime has been replaced by cement to a great extent during the last ten years, coral and sand have been maintaining their levels of use within this sector.

Coral and coral sand are extracted manually. Groups of people go out to the reefs in dhoanis (Maldivian fishery crafts) and dive to the limit of their breath to obtain the materials. The corals are then collected in the dhoanis and brought to the islands to be sold.

(b) Dredging. Dredging was first introduced to the Maldives in 1977 when the Government launched an airport development project, to serve the fast growing tourism industry. To achieve the desired length of runway, the shallow lagoon around the island of Hulule had to be reclaimed and this was done by dredging the reef flat. Subsequent dredging in the lagoon of Hulule was carried out to create an adequate harbour basin.

Further dredging has been carried out in the following locations.

1) Thulusdhoo, where dredging for a harbour basin took place.

2) Male, where dredging created harbour basins and land.

3) Darah, where dredging provided a harbour basin.

(c) Blasting. Blasting is used mainly to cut entrances in the reef edges, but where the material in the lagoon is too hard, this technique has also been used to disintegrate the material for easier dredging. Blasting was first introduced in mid-1984 and has been used in Thulusdhoo and Male.

The management of coral reefs has not yet been entrusted to any special agency. However, the Ministry of Fisheries has always taken a very special interest in the coral reefs of the country because of their importance in terms of fisheries. Recently an environmental commission has been set up under the Ministry of Home Affairs and Social Services whose function will be to advise the Ministry of environmental matters.

Table I.2 List of existing marine reserves in Indonesia

Name	Location	Size (in hectares)	Declared as marine reserve since	Major component to be preserved
Banda Sea	Central Maluku	2,500	April 1973	Coral Reef Underwater seascape
Pombo Island	Central Maluku	1,000	July 1973	Coral reef Incubator bird
Kasa Island	Central Maluku	2,000	October 1978	Coral reef Incubator bird Ambon lizard
Kepulauan Seribu (proposed National Park)	Jakarta	108,000	July 1982	Coral reef Mangrove Giant Clam Hawksbill turtle nesting beach
Semama Island	East Kalimantan	220	August 1982	Green turtle nesting beach Frigate bird nesting place
Sangalaki Island	East Kalimantan	280	August 1982	Green turtle nesting beach
Weh Island	Aceh (North of Sumatra)	2,600	December 1982	Coral reef Forest

Table I.3 Proposed marine reserves and marine parks in Indonesian waters

Location of marine reserves/marine parks	Number of sites	Total area of sites within one region (total in hectares)
Indonesian Ocean	41	425.32
Pacific Ocean	24	1 339.00
Java Sea	30	382.95
Bali Strait	2	10.00
Sunda Strait	2	38.00
Malaka Strait	10	195.76
Karimata Strait	14	267.01
Flores Sea	19	809.00
Sulawesi Sea	13	453.00
Tomini Bay	7	223.50
Maluku Sea	8	350.00
Makassar Strait	15	600.00
Tolo Bay	5	215.00
Bone Bay	1	5.00
Seram Sea	7	503.00
Sawu Sea	1	1.50
Timor Sea	2	21.50
Banda Sea	9	255.00
Arafura Sea	11	279.00
Lombok Strait	3	2.50
Buru Sea	1	4.00
TOTAL	225	6 380.000

(iv) Malaysia

The majority of coral reefs in Malaysia are of the shallow water fringing type, located around the offshore islands of the east and west coasts of the peninsular (which is on the mainland of South East Asia) and East Malaysia (comprising Sabah and Sarawak on the north west coast of Borneo).

Existing information about the coral reefs of Malaysia has been derived from less than 35% of the total coral reef areas. The surveys carried out to date have given information on coral species diversity; dead and live coral cover, and in some instances the causes of coral reef damage.

Pulau Perhentian, Pulau Redang, Pulau Tioman and Pulau Langkawi are the populated islands which are developing into tourist resorts. Already the following problems have been indentified on these islands.

(a) Dumping of waste, river run-off and discharge of sewage into the sea.

(b) Approaches and passages to the villages and popular beaches suffer severe coral damage as a result of dropping and dragging of boat anchors.

(c) The use of explosives to catch reef fish has also done considerable damage, although surveillance and banning of the practice is now exercised. Damaged reefs, however, show little signs of recovery.

The reefs of Pulau Kapas, Pulau Tenggol and Pulau Paya/Sengantang group of islands and several other islands which are uninhabited, now face threats of being damaged by tourist activities. Collection of corals and other reef animals as souvenirs and for sale in aquarium shops does occur but the extent of damage to the reef as a result is not obvious.

The major cause of damage to corals on reefs in the Malaysian peninsula is that resulting from the activities of the Crown of Thorns starfish Acanthaster planci. Numbers of animals on the reef are high compared with other reefs in the region. Since the reef areas involved are small, the authorities have embarked on a project whereby the starfishes are removed from the reef and buried on the land.

Malaysia has recognised the problems of reef degradation and in order to regulate human impact upon the coral reef, the government is considering the establishment of marine parks which are designed for multiple use (i.e. non-destructive fishing, recreational, educational and scientific research purposes).

(v) Thailand

Studies on coral damage in Thailand can be separated geographically into two areas; those in the Gulf of Thailand and those in the Andaman Sea. The two areas differ in terms of diversity of coral species with approximately 60 species recorded in the Gulf and over 200 species in the Andaman Sea.

The main kinds of coral reef damage in Thailand include:

(a) Destructive fishing methods (using explosives and poisons and trawling too close to coral reefs).

(b) Collection of coral for commercial purposes

(c) Pollution resulting from sedimentation and turbidity (from freshwater run-off and erosion; tin mining and dredging activities in the Andaman Sea); heated water (from industrial plant cooling in the Gulf); and domestic waste and sewage effluents from tourist complexes.

(vi) Philippines

Coral reefs play a vital role in the Philippines since people are dependent upon them for their food and livelihood. (More than 15% of the total annual fish catch is derived from coral reef communities). As a result of these statistics filipino scientists embarked on exploratory studies to determine the area covered by coral reefs within the archipelago of 7,100 islands. In 1979 the University of the Philippines Marine Science Centre (UPMSC) Coral Reef Project reported that the country is bordered by 27,000km^2 of coral reefs. This Institution then proceeded to investigate the conditions of these reefs, and from their study organised reefs into the following categories excellent (75-100% live coral cover), good (50-74%), fair (25-49.9%) and poor (0-24.9%) using quadrat methods of surveillance.

Results of the survey showed that Philippine reefs were in fair condition but in danger of degeneration. Possible causes of human induced coral damage were cited as siltation from poor agricultural practices; destructive fishing methods (blast fishing, fish traps such as 'muro-ami' and the local modified version called 'Kayakas'; poisons such as sodium cyanide used to catch aquarium fish) and coral extraction for construction and decorative purposes.

Since UPMSC concentrated on the fringing reefs, the Bureau of Fisheries and Aquatic Resources Coral Reef Research project (BFAR-CRRP) studied the shallow reefs (patch reefs), particularly those located in waters north and west of Palawan to supplement information on reefs in the country. The Palawan area was chosen because the concentration of reefs was particularly high in this region. Investigations were facilitated by a rapid visual census method involving the use of a manta board tow and subsequent coral cover estimation using quadrats. Reef condition criteria were similar to those used by UPMSC and results showed that condition of reefs in the area were generally fair. Observed coral damage during the survey was attributed to blast fishing and other destructive fishing methods as well as storm and typhoon damage.

(vii) Papua New Guinea

Papua New Guinea (PNG) has a coastline of 8,304km with numerous small islands and atolls in the Indo-West Pacific and as a result has rich coral reef resources. Human induced impacts on coral reefs are minimal when compared to other S.E. Asian countries. Nevertheless coral reef degradation is likely around island urban centres, particularly those running commercial tourism ventures.

Current use of coral or reefal materials is very limited but other coral reef species (e.g. shells, fish) are readily harvested. Over fishing for a number of reef fish species would appear to be the major impact on the reef. It has been estimated that PNG has some 17 million ha of reef which could yield 100,000 tons/year of fish. Present detrimental fishing activities involve either traditional methods, modern introduced techniques or a combination of both. Potential damage to reefs in PNG may be attributed to the following causes:

(a) Traditional Fishing Methods involving mechanical movement of coral heads/boulders on reef flats to collect trapped fish, echinoids and other reef invertebrates. In addition coral materials from the reef flat are used to construct mini-dams for giant clam culture (e.g. Manus Island), shoreline fronts, village squares, and house foundations. Another use of living coral (Acropora sp.) is for lime production which is chewed with betel nuts.

(b) Other fishing methods include the use of goggles, face masks and spear guns together with the use of derris root poisons and monofilament lines. The use of poles from canoes over shallow reef areas together with careless anchoring activities result in localised damage, and night spear fishing has recently increased considerably, resulting in a potential risk to scarids and other carnivorous reef fish which are night active. Explosives which were commonly used ten years ago are now not so regularly used.

(c) Tourism. The increase in both domestic and international tourism has resulted in a demand for souvenir collections of reef animals, including corals. Underwater, corals are used as 'resting places' during snorkelling activities where fins break off branching and foliose corals.

(d) Agriculture and forestry activities result in heavy loads of sediment being discharged into coastal waters. The extent of damage caused to reefs is unknown.

(e) Industrial development (i.e. construction of wharves, jetties), smelters and oil points construction are currently going ahead in PNG though their impact on the reefs is unknown.

Numerous safeguards for protection of reef areas do exist in PNG. These include the Environmental Planning Act 1978; the Environmental Contaminants Act 1978; Conservation Areas Act 1978; National Parks Act 1982. The Fauna Protection Control Act and the traditional nature of land ownership and fishing rights enable some control to be exercised over reef damage. However the number of trained personnel (currently 3 scientists, not all full time employees) working on coral reef related problems is inadequate to tackle the likely increase in tourism and industrialisation in coastal zones, which the country will face in the coming years. There is an urgent need for training programmes in coastal zone problems and management. Institutes presently involved in coral reef research in PNG include the University of Papua New Guinea's marine research station at Motupore Island (near Port Moresby); Laing Island Research Station (operated privately by the University of Belgium in Madang province) and the Fisheries Department of the University of Technology at Lae.

CHAPTER TWO

MEASURING GROWTH RATES OF REEF CORALS AS AN INDICATION OF THE EFFECTS OF POLLUTION AND ENVIRONMENTAL DISTURBANCE

A) B.E. Brown
Department of Zoology
University of Newcastle Upon Tyne
Newcastle Upon Tyne
United Kingdom

B) T.P. Scoffin
Grant Institute of Geology
University of Edinburgh
Edinburgh, Scotland
United Kingdom

Introduction

The growth rate of corals has been cited as one of the best quantitative measures of assessing 'stress' due to disturbance because this parameter integrates a variety of physiological processes (Birkeland et al 1976); Neudecker 1983, Brown and Howard 1985). It is however widely accepted that coral growth rates may be inherently variable (Buddemeier and Kinzie 1976; Barnes and Crossland 1982) both for a single species within reef zones (Gladfelter et al 1978) and even within individual colonies (Rogers 1979; Brown et al 1983).

In this summary of two lectures given during the workshop two techniques of measuring coral growth are described and their possible applications discussed.

A) The use of alizarin staining for measuring coral growth

We should first begin by considering what we mean by coral growth - for growth will involve an increase in dimension of both tissue and skeleton. The two are not necessarily independent for the skeleton will not form without the tissues which closely overlay and secrete the calcium carbonate (Figure 2:1).

We can measure both tissue and skeleton growth by regular weighings of corals underwater (buoyant weight techniques) or alternatively we may choose to measure skeletal growth alone. An assessment of skeletal growth may involve measurements of calcification, linear extension and weight of skeleton accreted.

A widely used technique to measure growth in both branching and massive corals is alizarin staining. In 1974 Lamberts showed that living corals incorporated the dye alizarin red S into their skeleton. The dye left a pink time marker, from which growth could be subsequently measured. With either massive or branching corals the technique involves placing polythene bags (or staining tents if the massive corals are exceptionally large) over individual colonies or parts of colonies with a measured quantity of alizarin powder secured in the corner of the bag with an elastic band (Figure 2·2) When the polythene bag is full of sea water the alizarin powder can be released; the dye then slowly diffuses into the seawater surrounding the coral colony, the base of which is sealed within the polythene bag with a rubber band. the final concentration of the stain in the bag should be ≏ 10-15 mgl^{-1}. Branching

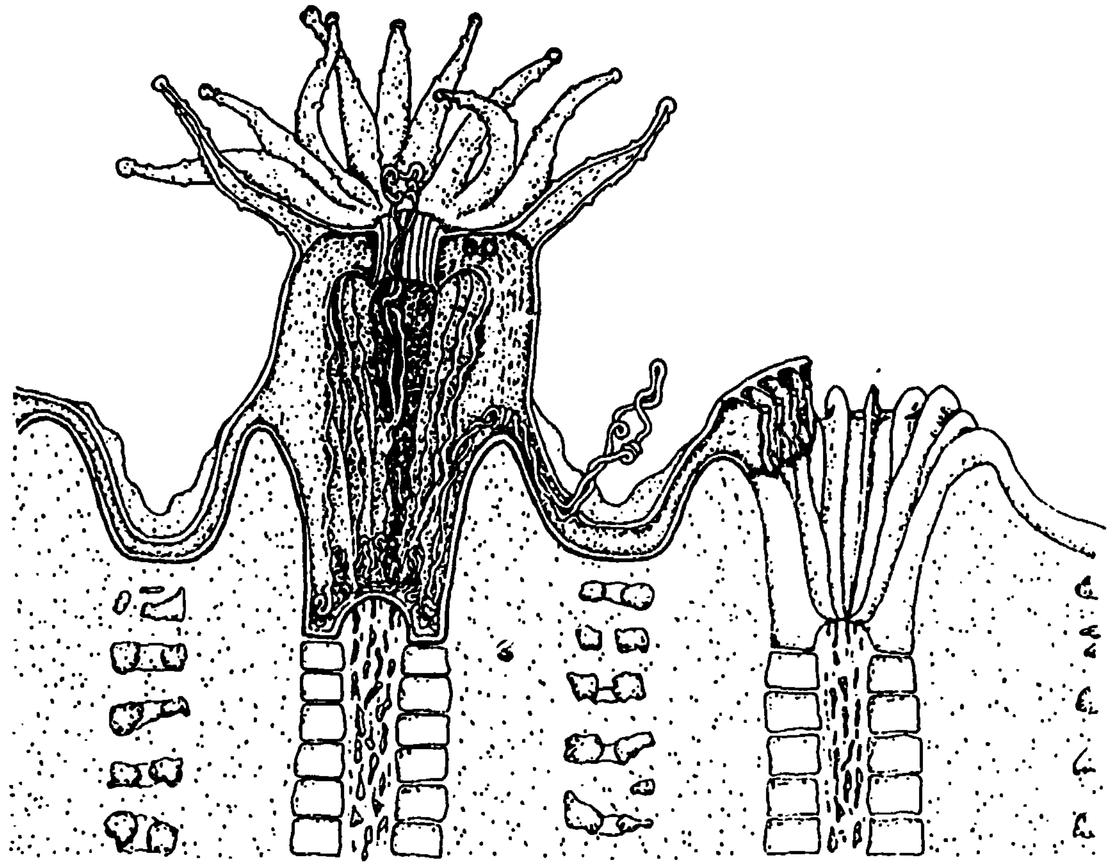


FIGURE 2.1 LONGITUDINAL SECTION THROUGH A CORAL POLYP SHOWING THE CLOSE ASSOCIATION BETWEEN TISSUES AND SKELETON (after Goreau et al 1979)

s = skéleton
cp = coral polyp

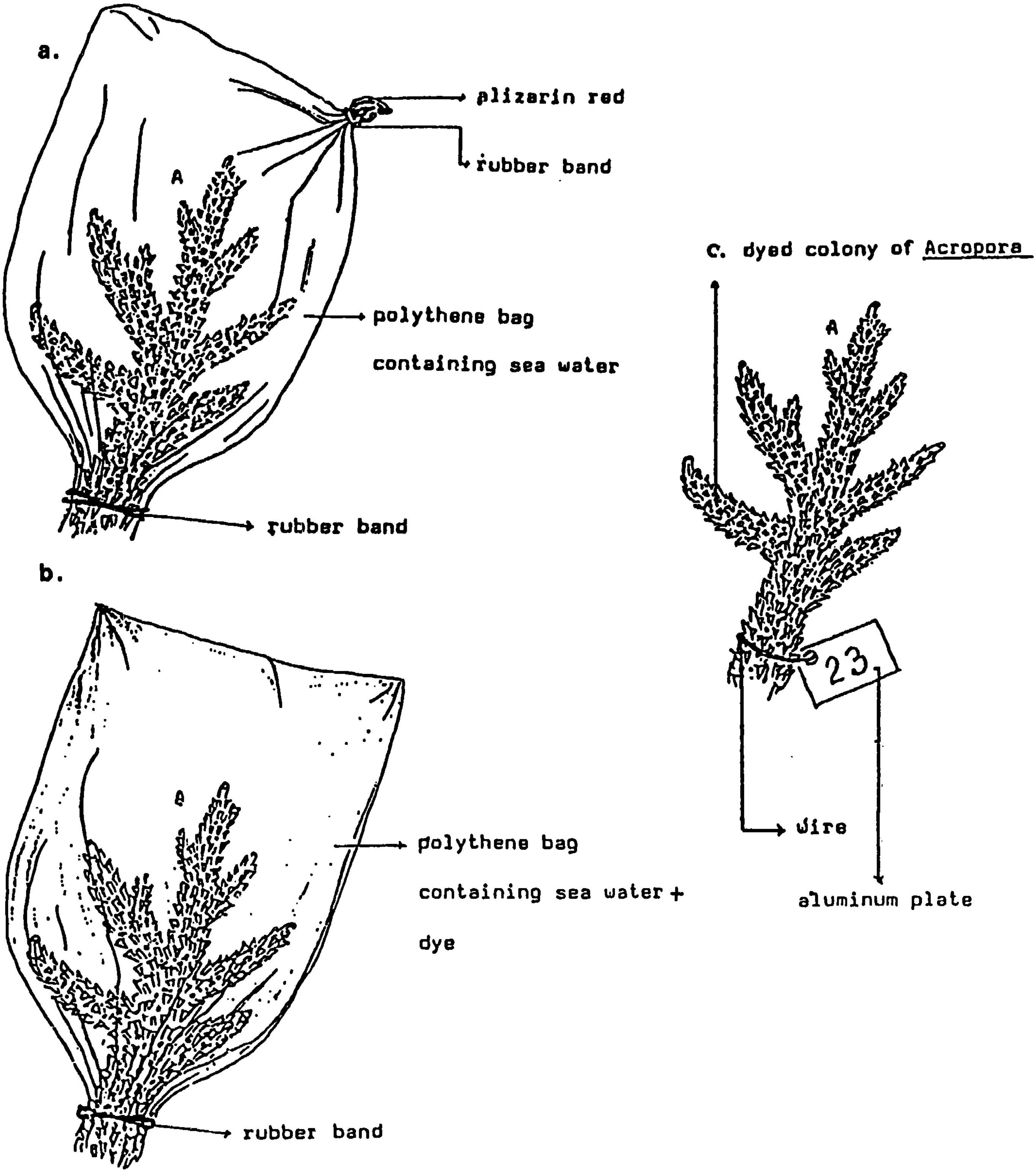


FIGURE 2.2 STAGES IN THE ALIZARIN STAINING PROCESS:

(a) The unreleased dye and polythene bag filled with seawater around the branching coral.

(b) The dye is released while the base of the bag is still secured and the coral allowed to take up the stain.

(c) The bag is removed, the coral tagged for subsequent relocation and allowed to grow for a period before being sacrificed for growth measurement.
(after Sya'rani 1983)

corals may be left in the stain for 8h before release, whereupon they should be tagged for subsequent relocation at a later date. A similar staining period is adequate for massive corals; it is noteworthy that where massive corals have been left in alizarin stain for periods of 12-24h that 'stress' bands have been reported in the skeleton as well as reduced calcification rates in some colonies. (Hudson 1981; Dodge et al 1984). However if corals are maintained in stain for a minimum time with an adequate period allowed for recovery and subsequent growth measurement (e.g. for branching species allow 4-8 weeks growth depending on the habitat) then useful comparative measurements may be obtained for corals in different environments. After such a period of growth in branching corals two parameters may be measured:

a) Linear extension - by measuring the distance between the pink marker band and the tip of the branch. Since growth within a colony is very variable it is always wise to choose unbranched apical branch tips for comparative growth rate measurements for these branches generally represent the most rapidly growing part of the colony (see Chapter V). In addition care should be taken to take only similarly coloured tips (i.e. white or brown) since Oliver (1984) has shown differently coloured tips have different growth characteristics.

b) Skeletal accretion - by removing the portion of skeleton accreted between the marker band and the tip using a junior hacksaw and fine file and subsequently weighing this recent growth. Great care should be taken when handling apical tips since these are very fragile as they are the most recently calcified part of the colony.

Some examples of the results that may be obtained with alizarin staining methods are shown below:

Comparison of growth rates between sites

Figure 2.3 show differences in growth rate of a branching coral species found in the Java Sea *Acropora aspera*. Growth is measured as skeletal extension and skeletal accretion and is compared between four sites around the Pulau Pari complex in the Kepulauan Seribu. The most rapid growth occurred at site D or South Tikus which is relatively protected from monsoon influences, when compared with other sites in the island complex. In addition it should be noted that although there is no significant difference in skeletal extension between outer reef flat and reef edge sites there are significant differences in skeletal accretion values between these locations on the reef. (Brown et al 1985).

Comparison of growth rates at one site over time

Seasonal influences on growth of a Caribbean coral *Acropora cervicornis* can be seen in Figure 2.4 where average monthly rates of skeleton extension and accretion are shown. In this species linear extension did not change during the year but calcium carbonate accretion did show significant seasonal variation. Calcium carbonate accretion was most strongly correlated with duration of sun hours. In similar studies on the N. Java coast in Indonesia results suggest that coral growth rates are maximal in the dry season and minimal during the wet season. Such studies indicate the importance of long term measurements of growth, where variation due to natural fluctuations can be established before considering the effects of disturbance.

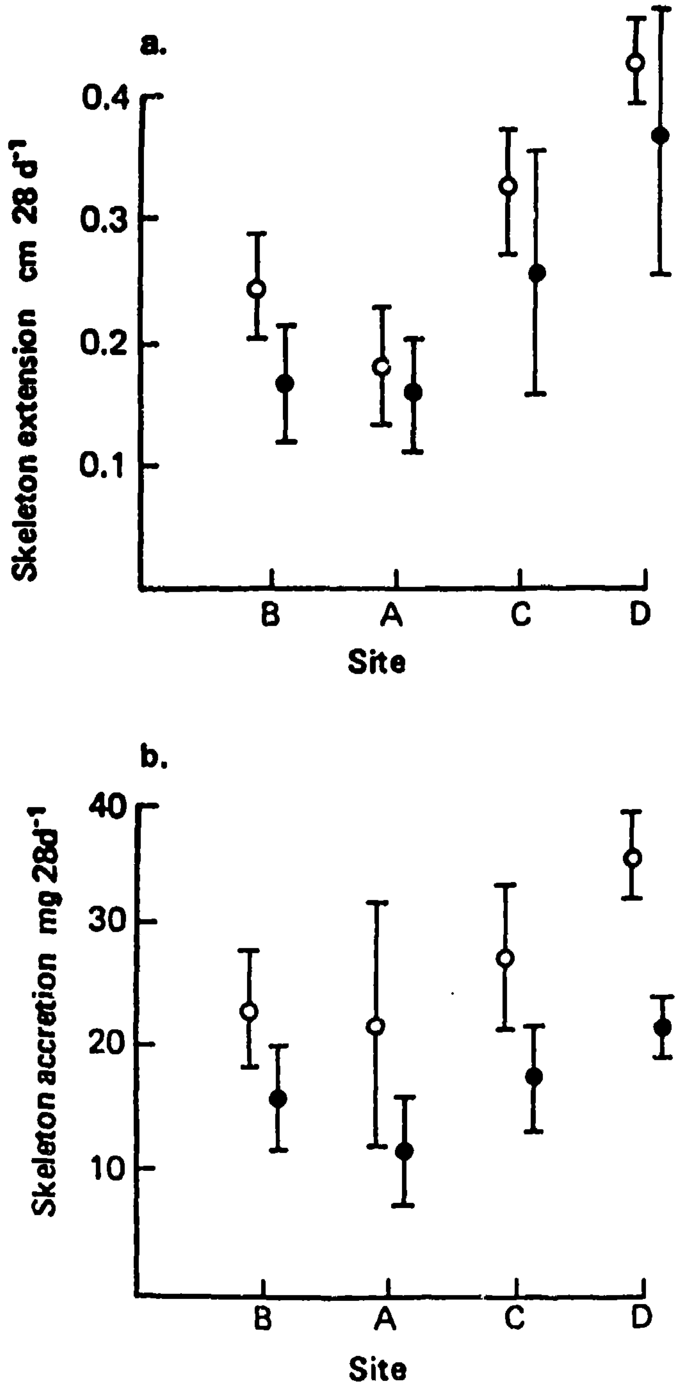


FIGURE 2.3 COMPARISON OF CORAL GROWTH AT DIFFERENT SITES:

(a) Skeletal extension (cm 28 days $^{-1}$) of Acıopora aspera branches at North Pari (A), North Tikus (B), South Pari (C) and South Tikus (D).

(b) Skeletal accretion (mg 28 days $^{-1}$) of Acropora aspera branches at the same sites.

Points shown are mean values $\pm$ SD n = 20
outer reef flat
reef edge

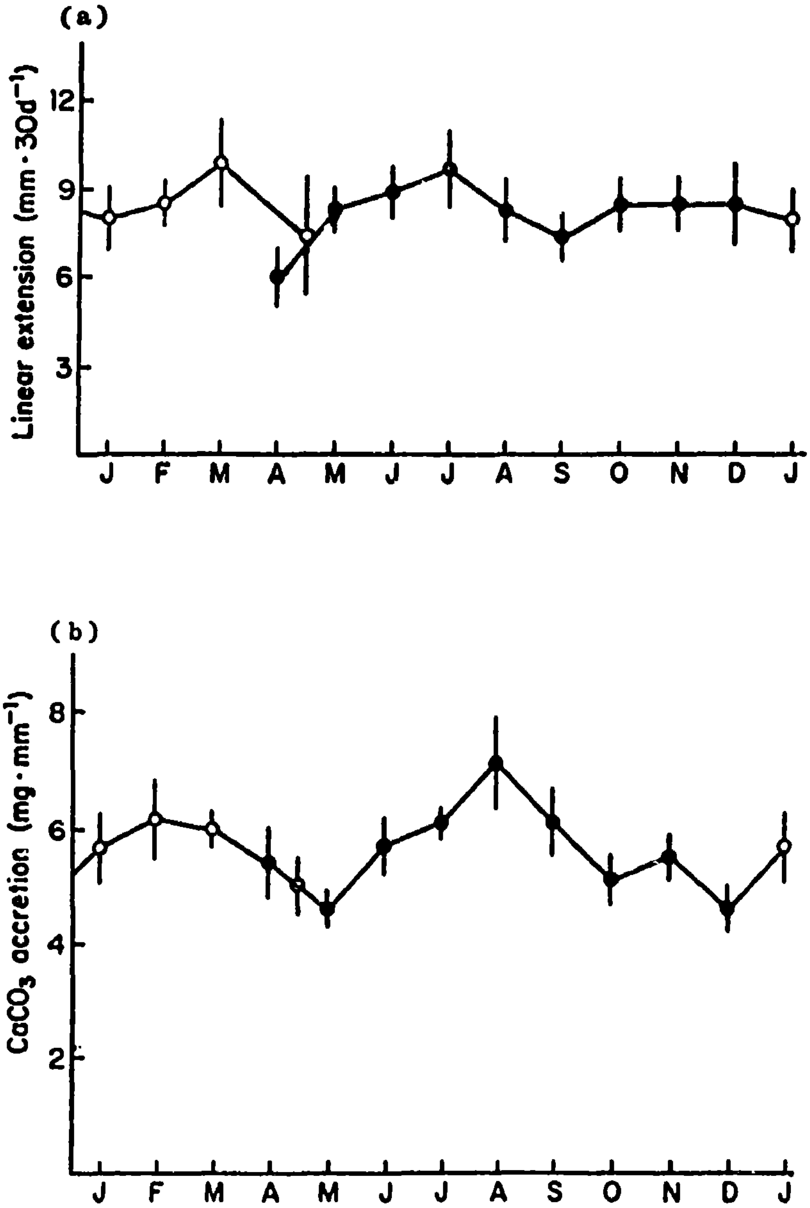


FIGURE 2.4 COMPARISON OF GROWTH RATES IN A COLONY OF ACROPORA CERVICORNIS OVER ONE YEAR:

(a) Rate of linear extension of the axial corallite A. cervicornis.

(b) Specific accretion of $CaCO_3$ (wt. $CaCO_3$ per unit extension) on the axial corallite.

Values plotted are the mean and 95% confidence limits.

• 1979

o 1980

(after Gladfelter 1984)

The measurements of growth in transplanted corals, as an aid to the interpretation of growth rate measurements in suspected polluted environments

Branching corals can be usefully transplanted to new environments after staining and this has been employed by several workers including Neudecker 1983, Oliver et al 1983, Yap and Gómez 1984; and Yap and Gomez 1985. Again care must be taken over minimising the stresses associated with transplantation. Adequate time for recovery and growth must be allowed as well as avoiding transfers during the warmer months of the year (Yap and Gomez 1985).

Figure 2.5 shows the results for growth of transplanted corals (Acropora pulchra) and 'in situ' corals at Ko Phuket Thailand. Sites A and C represent locations receiving high and low sediments loads respectively. The effects of sedimentation are reflected in the lower 'growth' values of coral from site A. Interestingly the effect of transplanting corals from site A to C is not only to increase their linear extension over that achieved by 'in situ' corals but to markedly increase their skeletal accretion to values above even 'in situ' site C corals. Such results suggest, as other workers have noted, that skeletal extension and skeletal accretion may be under different controls. (Gladfelter 1984; Brown et al 1985). Furthermore the results also indicate that skeletal accretion may be more sensitive to light levels than skeletal extension - a fact also observed by Gladfelter (1984) and Brown et al (1985). The marked increase in skeletal accretion by transplanted corals seen in Figure 2.5 may be a stimulation in growth as a result of removal of an inhibitor/s (e.g. reduced light availability and sedimentation). Such effects have previously been observed in hydroids where cyclical fluctuations in growth of stressed colonies have been shown to match a simple stimulation growth control model (Stebbing and Hilby 1978).

Not only then can transplant experiments give us some insight into growth differences between different environments but they may provide data upon which to develop testable hypotheses on the fundamental controls of growth.

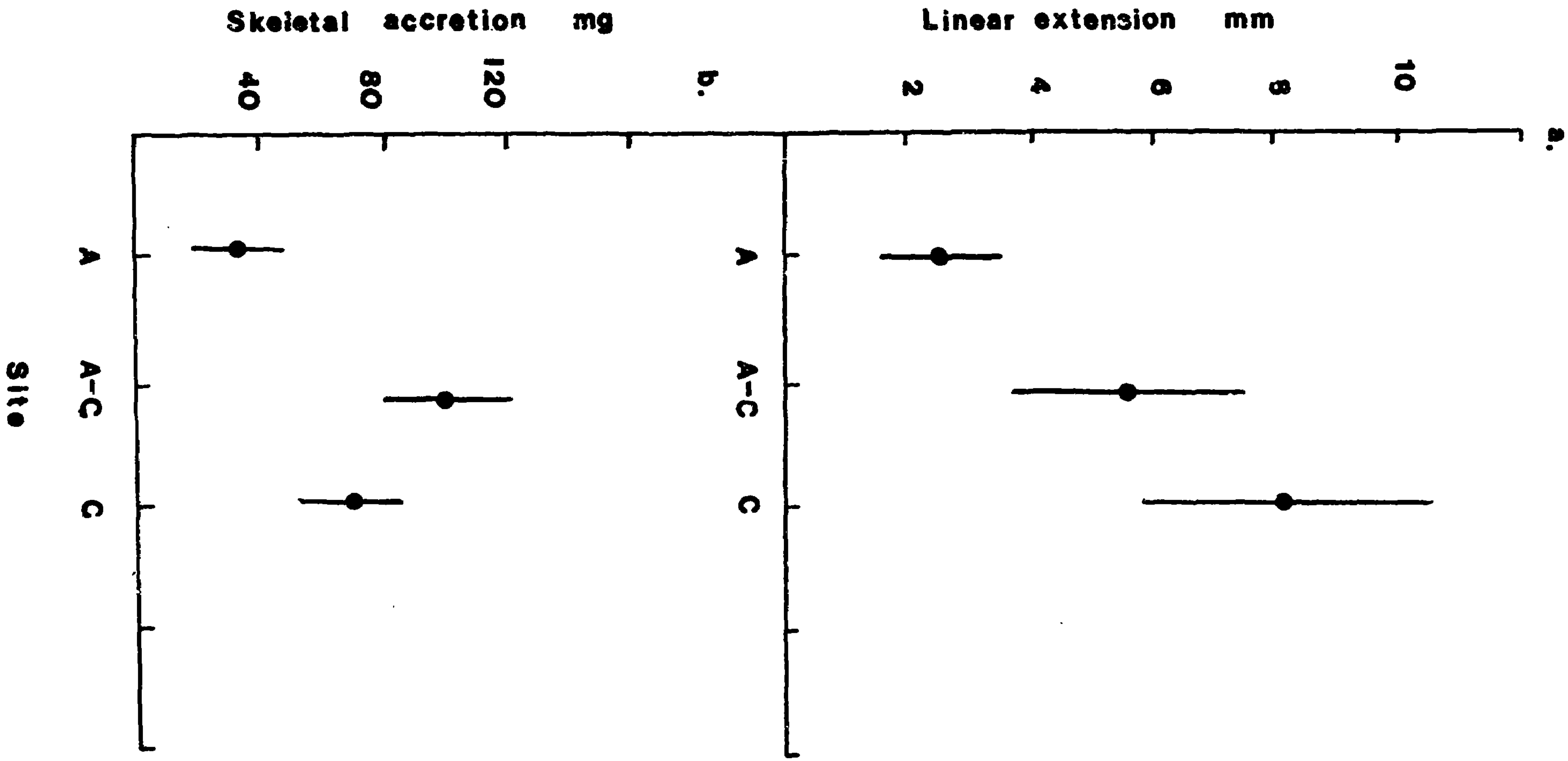


FIGURE 2.5 CORAL GROWTH IN 'IN SITU' AND TRANSPLANTED CORALS AT KO PHUKET, THAILAND

(a) Average skeletal extension (cm 28 d^{-1}), of Acropora aspera at site A (high sediment load) and site C (low sediment load) and specimens transferred between site A and C.

(b) Average skeletal accretion (mg 28 d^{-1}) of Acropora aspera at site A, site C and specimens transferred between site A and C.

B) <u>Coral sclerochronology: an introduction</u>

Sclerochronology, the study of the age relations of skeletal growth, has been used to great effect in stony corals to reconstruct their growth history (Buddemeier and Kinzie 1976, Dodge and Vaisnys 1980), to interpret and date the changing physical and chemical environments of growth(Hudson et al 1976, Wellington and Glynn 1983) and to assess the rates of $CaCO_3$ accretion in individual colonies (Highsmith 1979) and, by extrapolation, reefs as a whole (Stearn et al 1977). Growth history can be studied by direct measurements made on living corals in the field or laboratory over unit time or retrospectively by measurements on increments of growth recorded within skeletons between points representing known dates.

In growth-monitoring experiments the dimensions measured on living corals include a) linear growth, b) surface area, c) volume of colony, d) weight. Many of these measurements are made directly on corals in the field. Long-term estimates may be made by comparing photographic records over periods of months or years, though periods of skeletal erosion may be included in such analyses. A marker may be planted in the living coral skeleton (e.g. a metal stake) and growth simply compared to this. A more delicate marker on the coral may be introduced by staining the coral for a period of a few hours in Alizarin red S (see above). The coral has later to be sacrificed when it is collected and sliced open to reveal the position of the stained horizon within the skeleton, and the extent of subsequent growth measured. This staining method does allow marker bands to be incorporated in corals at convenient times of the year, also, they may be repeated over set periods within one colony before it is collected, thus short-term growth variations can be assessed. However we do not know the likely effect on skeletal growth of the coral being subjected to alizarin red S - stained water for a few hours. It may be insignificant but the shock may retard calcification or conversely the injurious effects may promote more rapid 'repair' growth.

In the laboratory it is possible to record accurately the uptake of tracer substances such as dyes (Lamberts 1974) or radioisotopes, e.g. ^{45}Ca, (Barnes and Crossland 1977, Chalker 1983) into the skeleton. A major problem with these tracer measurements on living corals is that growth perturbations may be induced during experimentation. An alternative estimate of the skeletal accretion rate can be made by observing the changes in surrounding water chemistry (pH and alkalinity) which are consequences of $CaCO_3$ extraction by the coral during skeletogenesis (Smith 1978).

Retrospective methods of coral sclerochronology involve examining past growth increments recorded in the skeleton. One method detects inclusions within the coral skeleton of foreign material (Barnard et al 1974) whose time of incorporation is well known, for example, detrital sediment relating to a volcanic ash fall, or an increased incorporation of radionuclides (notable ^{228}Ra and ^{210}Pb) from fallout associated with nuclear tests (Buddemeier and Kinzie 1976). Another method utilizes the seasonality of density bands within the skeleton as revealed by X-radiography. This is currently the most widely adopted method of coral sclerochronology (Buddemeier 1974, Buddemeier et al 1974, Knutson et al 1972, Macintyre and Smith 1974). Corals are collected and sliced longitudinally parallel to their axes of growth into slabs of even thickness which can be between 5 and 15 mm thickness. Where slabs are thick, the density banding becomes more diffuse as the likelihood of the cut being exactly 90° to band orientation throughout is reduced, where the slab is too thin, finer banding (possibly related to lunar cycles) is revealed which may confuse the broader seasonal imprint. The slabbed corals are placed, with an aluminium step wedge, on X-ray film (e.g. Kodak type AA film) and exposed to X-rays in a sealed X-ray machine (Buddemeier 1978). Typical exposures are for 15 to 50 seconds at 45 KV and 3 Ma with a source-to-film distance of 1 m. Naturally, thin slabs require less exposure than thick slabs, and experimentation is necessary to obtain the best results. In order to quantitatively relate densities, negatives of the coral images and aluminium standards are scanned with a transition densitometer. When calibrating standards, care has to be taken since X-ray intensity is not always uniform over the entire field.

The pattern of density banding clearly indicates the stages in growth of the coral. We can see typical patterns developed according to whether growth is essentially radial or axial; we note hiatuses in growth recorded as disconformities - commonly seen in shallow water corals which ceased growth for a period on account of exposure or localised sediment cover, and in coralliths which ceased movement for a period; we can see changes in growth orientation as in microatolls and also note repair growth around skeletal injuries. Comparison of density bands with stain experiments indicates that the low density bands (LD) within the coral represent an increase in linear extension ($mm. mo^{-1}$) as well as a marked increase in calcification rate ($g\ CaCO_3\ mm^{-2}\ mo^{-1}$) relative to the high density portion (H.D.). The low density portion is thought to accrete over a shorter period than the high density portion.

There is still considerable controversy as to the exact cause of the variation in density of the skeleton. It is generally believed (Buddemeier and Kinzie 1976, Macintyre and Smith 1974, Buddemeier 1974, Wellington and Glynn 1983) that the high density bands are produced under conditions of stress and the lower density bands accrete during optimum growth conditions. The environmental factors which influence the calcification in the coral could be a) light (Bak 1974), b) temperature (Highsmith 1979), c) salinity, d) levels of suspended sediment. Other factors which influence the metabolism of the coral are nutrient availability and sexual activity (the production of gametes diminishes energy available for growth and calcification) (Wellington and Glynn 1983). The role played by the symbiotic zooxanthellae in influencing calcification adds a further complicating ingredient. Maximum calcification will occur at optimum environmental conditions (which will vary for different coral species). Some of these environmental factors may have narrow limits with both maximum and minimum threshold of tolerances such that calcification will decrease outside (i.e both above and below) these limits. So lowered light levels, as for example during rainy seasons when cloud cover is greatest, may cause high density bands (Stearn et al 1977), but similar skeletal effects may occur on photoinhibition when light levels are too high. Similarly both too low (upwelling) and too high (El Nino) water temperatures, and too low and too high salinities may inhibit growth. It could depend upon which environmental threshold the coral lives closest to as to how its density bands are produced. Each stress can create a dense band but one particular factor may be the overriding one in any particular environment producing a relatively more dense portion of skeleton. It may be that it is on the coincidence of two or more stressful factors that calcification is significantly influenced for a dense band to form. It is clear from the above that the causal interpretation (environmental or endogenous) of density banding is difficult. Clearly, if there is a statistically significant correlation between the pattern of local rainfall and the arrangement of skeletal density bands then correlations between calcification patterns and light levels can be drawn. Though there still may exist the possibility of a different effect consequent on high rainfall (such as low salinity, changes in temperatures or suspended sediment levels) being the real cause of calcification changes.

Where possible it is advisable to implant stain markers within skeletons that are later to be X-rayed. This gives a dated control and allows a more meaningful interpretation of the timing of density bands. Most studies that have adopted this approach have shown that a couplet of HD and LD bands (approximately 10-12 mm wide for most massive corals) represents a years' increment of growth. However several reported experiments show that the HD band in, for example, corals on one part of a bay or on one side of a peninsular, can form at a different time of year to the H.D. band in corals in a geographically nearby location but one with a significantly different history of changing (seasonal?) environments, just the other side of the bay or peninsular. Nonetheless, once the seasonality of density couplets has been proved, then growth rates over the coral's life span can be measured and changing growth rates within and between colonies can be environmentally interpreted with some confidence.

Where corals have grown in waters that have been within the range of fresh water run-off from the land then organic compounds produced by fresh water plants in soils, such as fulvic and humic acids, may be incorporated into the coral skeleton (Boto and Isdale 1985). Certain of these compounds fluoresce under ultra-violet light (for example low-relative molecular mass fulvic acids give a yellow-green band) which cause a bright/dull banding in corals which relates to rainfall, river discharge and proximity to land (Isdale 1984). Initial studies (on corals living adjacent to a simple shoreline) show a good correlation between bright u/v bands and periods of high rainfall on the land. This observation allows the reconstruction of past climates and changes in rainfall or run-off patterns (e.g. related to deforestation) over long periods (hundreds of years for large massive corals). As well as indicating the temporal pattern of fresh water discharge, this technique with an appropriate distribution of samples, potentially allows an assessment of the areal variation in fresh water discharge over time.

References

Bak, R.P.M. (1974). Available light and other factors influencing growth of stony corals through the year in Curacao. Proc. 2nd Int. Symp. coral Reefs Brisbane 2, 229-233.

Barnard, L.A. Macintyre, I.G. and Pierce, J.W. (1974). Tropical reef corals; non-carbonate detrital fraction and its significance as an environmental index. Nature, 252, 219-220.

Barnes, D.J. and Crossland, C.J. (1977). Coral calcification: sources of error in radioisotopic techniques. Mar. Biol. 42, 119-129.

Barnes, D.J. and Crossland, C.J. (1982) Variability in the calcification rate of *Acropora acuminata* measured with radioisotopes. Coral Reefs. 1, 53-57.

Birkeland, C., Reimer, A.A. and Young, J.R. (1976). Survey of marine communities in Panama and experiments with oil. Environmental Protection Agency Ecological Research Series.

Boto, K. and Isdale, P. 1985. Fluorescent bands in massive corals result from terrestrial fulvic acid inputs to nearshore zone. Nature, 315, 396-397.

Isdale, P. 1984. Fluorescent bands in massive corals record centuries of coastal rainfall. Nature 310, 578-579.

Knutson, D.W., Buddemeier, R.W. and Smith, S.V. (1972). Coral chronometers: seasonal growth bands in reef corals. Science 177, 270-272.

Lamberts, A.E. (1974). Measurements of alizarin deposited by coral. Proc. 2nd Int. Symp. Coral Reefs. Brisbane. Ed. A.M. Cameron, 2, 241-244.

Macintyre, I.G. and Smith, S.V. (1974). X-radiographic studies of skeletal development in coral colonies. Proc. 2nd Int. Coral Reef Symp. Brisbane. 2, 277-287.

Neudecker, S. (1983). Growth and survival of scleractinian corals exposed to thermal effluents at Guam. Proc. 4th Int. Coral Reef Symp. Manila. 1, 173-180.

Oliver, J.K., Chalker, B.E. and Dunlap, E.C. (1983). Bathymetric adaptations of reef building corals at Davies Reef, Great Barrier Reef, Australia. 1. Long term growth responses of Acropora formosa (Dana 1846). J. exp. mar. Biol. Ecol. 73, 11-35.

Roger, C.S. (1979). The effect of shading on coral reef structure and function. J. Exp. Mar. Biol. Ecol. 41, 269-288.

Smith, S.V. (1978). Alkalinity depletion to estimate the calcification of coral reefs in flowing waters. In D.R. Stoddart and R.E. Johannes (Eds.). Coral Reefs: Research Methods. UNESCO, Paris. 397-404.

Stearn, C.W., Scoffin, T.P. and W. Martindale, (1977). Calcium carbonate budget of a fringing reef on the west coast of Barbados. I - zonation and productivity. Bull. Mar. Sci. 27, 479-510.

Stebbing, A.R.D. and Hiby, A.R. (1978). Cyclical fluctuations in the growth rate of stressed colonies. In 'Cyclic Phenomena in marine plants and animals' Ed. Naylor, and R.G. Hartnoll. Proc. 13th European Mar. Biol. Symp. Pergamon Press.

Supriharyono (in press). The effects of sedimentation on a fringing reef in North Java Ph.D. Thesis Univ. of Newcastle Upon Tyne.

Sya'rani, L. (1983). Ecology of shallow water coral communities in the Java Sea. Ph.D. Thesis Univ. of Newcastle Upon Tyne.

Wellington, G.M. and Glynn, P.W. (1983). Environmental influences on skeletal banding in eastern Pacific (Panama) corals. Coral Reefs 1, 215-222.

Yap, H.T. and Gomez, E.D. (1984). Growth of Acropora pulchara II Responses of natural and transplanted colonies to temperature and day length. Mar. Biol. 81, 209-215.

Yap, H.T., and Gomez, E.D. (1985). Growth of Acropora pulchra III Preliminary observations on the effects of transplantation and sediment on the growth and survival of transplants. Mar. Biol. 87, 203-209.

Brown, B.E. and Howard, L.S. (1985). Assessing the effects of 'stress' on reef corals. Adv. mar. biol. 22, 1-63.

Brown, B.E., Hewit, R., and Le Tissier, M.D. (1983). The nature and construction of skeletal spines in Pocillopora damicornis (Linnaeus) Coral Reefs 2, 81-89.

Brown, B.E., Sya'rani, L. and Le Tissier, M. (1985). Skeletal form and growth in Acropora aspera (Dana) from the Pulau Seribu, Indonesia. J. Exp. mar. Biol. Ecol. 86, 139-150.

Buddemeier, R.W. (1974). Environmental controls over annual and lunar monthly cycles in hermatypic coral calcification. Proc. 2nd Int. Coral Reef Symp. Brisbane, 2, 259-267.

Buddemeier, R.W., Maragos, J.E. and Knutson, D.K. (1974). Radiographic studies of reef coral exoskeletons : Rates and patterns of coral growth. J. Exp. Mar. Biol. and Ecol. 14, 179-200.

Buddemeier, R.W. and R.A. Kinzie III. (1976). Coral growth. Oceanogr. Mar. Biol. Ann. Rev. 14, 183-225.

Buddemeier, R.W. (1978). Coral growth: retrospective analysis. In D.R. Stoddart and R.E. Johannes (Eds) Coral reefs: research methods. UNESCO, Paris.

Chalker, B.E. (1983). Calcification by corals and other animals on the reef. In D.J. Barnes (Ed.) Perspectives on coral reefs. Brian Clouston, A.C.T., 29-45.

Dodge, R.E. and Vaisnys, J.R. (1980). Skeletal growth chronologies of Recent and fossil corals. In D.C. Rhoads and R.A. Lutz (Eds.) Skeletal growth of aquatic organisms. Plenum, New York 493-517.

Dodge, R.E., Wyers, S.C., Firth, H.R., Knap, A.H., Smith, S.R., Cook, C.B. and Sleeter, T.D. (1984). Coral calcification rates by the buoyant weight technique : effects of alizarin staining. J. Exp. Mar. Biol. Ecol. 75, 217-232.

Gladfelter, E.H. (1984). Skeletal development in Acropora cervicornis: a comparison of monthly rates of linear extension and calcium carbonate accretion measured over a year. Coral Reefs 3, 51-57.

Gladfelter, E.H., Monahan, R.K. and Gladfelter, W.B. (1978). Growth rates of five reef building in the northeastern Caribbean. Bull. Mar. Sci. 28, 728-734.

Goreau, T.F., Goreau, N.I. and Goreau, T.J. (1979). Corals and coral reefs. Scientific American 241, 124-136.

Highsmith, R.C. (1979). Coral growth rates and environmental control of density banding. J. Exp. Mar. Biol. Ecol. 37, 105-125.

Hudson, J.H.H. (1981). Response of Montastrea annularis to environmental change in the Florida Keys. Proc. 4th Int. Coral Reef Symp. Manila. 2, 233-248.

Hudson, J.H., Shinn, E.A., Halley, R.B. and Lidz, B. (1976). Sclerochronology: a tool for interpreting past environments. Geology 4, 361-364.

CHAPTER THREE

ENVIRONMENTAL ASSESSMENT AND ANALYSIS IN RELATION TO COASTAL ZONE MANAGEMENT

J.R.E. Harger
UNESCO/ROSTSEA
Jl. M.H. Thamrin 14
Jakarta

Introduction

The nature of the problem determines in large part the type of information that must be gathered in order to effect a solution. If correctly handled, the analysis and subsequent evaluation of the material acquired during initial stages of an investigation are straight-forward procedures and result from the logic of the data base. However, if the data base does not adequately reflect the principal physical and biological variables no amount of manipulation will result in a satisfactory conclusion. Insofar as the coastal environment is concerned, or indeed the analysis of any other systematic environmental problem, the key to successful management lies in the initial definition of the problem. Once the basic inputs of proposed development are known, the structure of the data base required to generate insight into possible resource conflicts can be assembled in a straight-forward manner. Application of well known statistical procedures will then result in a rigorous definition of the background trends and patterns which are to be found in the relevant environmental factors which intersect and may interact with aspects and combinations of the principal components of the proposed project.

It is, however, all very well to speak in an abstract "text book" fashion but, you will say, we live in a real world. What exactly does this mean in the context of Coastal Management in Indonesia? The answer to this question is complicated but may be evaluated under three headings. In Table III.1, I have listed three categories of coastal management problems, in the order which we would most like to encounter them. The truth of the matter is, however, that we are seldom if ever faced with the option of working with problems associated with the first level in any but an entirely theoretical and academic context. In point of fact, our likelihood of professional encounter with these levels is highest with regard to the third category and somewhat less likely with the second, and unfortunately somewhat rare in the case of the first. It must be admitted also that the situation represented by the first category is the one which attracts the most theoretical interest; that being the case, I will commence my analysis of the overall field at this point.

PRIOR PLANNING PROBLEMS

It is seldom that a professional consultant is presented with a virgin situation, which may be represented by a stretch of coast line for instance wherein no major projects for industrial or other developments exists, and where a sufficient lead time plus financial input can be combined to generate an overall planning and management strategy. Such an hypothetical situation, however, provides us with the opportunity to examine the data acquisition process which should be evoked in conjunction with the appropriate analytical procedures. We can divide the important coastal considerations into 6 strata for the purpose of this examination.

Table III.1. Break down of planning and management problems in coastal zones

---

A. Prior planning problems

(1) Overall assessment required, nothing known, no development exists. Unknown developments posited.

(2) Assessment required in order to decide location of one (or less likely several, perhaps competing) development projects.

B. Procedural assessment problems

(1) Location of development project presented as a fait accompli. Assessment of possible effects required.

C. Post-operational assessment problems

(1) Assessment of the effects of already established installations together with an analysis of interactions with other projects.

---

1) physical considerations relating to marine processes;
2) considerations relating to the marine/freshwater interface;
3) physical considerations relating to the aquatic/terrestrial interface;
4) considerations relating to geological factors;
5) considerations relating to meteorological factors and the atmospheric/ marine interface;
6) considerations relating to biotype factors.

At once it will be imagined that the above scheme threatens to become unmanageable because of the potential interactions (ranging all the way from first order, i.e., 1 x 2, through second 2 x 3 x 6 up to 5th order etc.). Obviously, the levels of complexity that can apparently exist insofar as an overall analysis is concerned are high since the above list does not pretend to be exhaustive by any manner of means. The problem becomes even more formidable when particular individual subsets of each of the above noted categories are examined.

What can be done, in order to simplify the above structural relationships so as to make data acquisition and analysis fall into a context that can be readily grasped by both managers and executive officers alike? The principal problem that we have to deal with here is that nature is infinite in its capacity to be sub-divided and catalogued. We can, if we so desire, spend millions of dollars and man-hours simply describing the elements of any coastal region first by means of extensive raw data acquisition within each of the above categories and, secondly, by the application of number crunching computer analyses designed to service ever larger data base inputs. Obviously, use of such a mindless approach will lead to the creation of a monstrous assessment programme which will swallow up both funds and manpower. The net result of such a management strategy is usually to be found in the production of enormously expensive computer models which in themselves lend little useful insight to the situation.

The correct approach, in my view, is to introduce a process of simplification applied initially to each of the above noted categories or fields of analysis. This can be summarized under only three headings:

(1) Factor Identification
(2) Trend Analysis
(3) Pattern Analysis

Let me expand some of these points: the use of trend analysis is advised because we wish to be able to describe the time based interactions between potential site locations and the physical and biological environments. Naturally, in the case of virgin territory, every point in the coast line continuum is a potential location for some new development or project. We may therefore choose to consider such physical boundaries as represented by the sea shore (terrestrial-marine interface) as trends in themselves along which we may shift our project sites in search of appropriate interaction points. Such interaction points may involve the intersection of a few or more additional active trends. The degree of activity of a particular trend at a intersection point may be high or low. Once the interaction points are identified, the next step involves the numerical evaluation of the relevant trends in this region, followed by interaction assessment. There are plainly a number of trend expressions and combinations that can be regarded as negative with respect to their acceptability insofar as site location criteria are concerned. Let us take a concrete example, that of the location of a nuclear power plant having once-through cooling capability, which results in the heating of very large volumes of water. Under the headings of "favourable" and "unfavourable": the trend activities for each factor considered to be important may be listed. To simplify the situation, a few of the major factors only are considered in the example. These are shown in Table III.2.

As can be readily appreciated from consideration of this table, it is not of general significance to seek either high or, alternatively, low activity in the variable of interest. This is because either form of activity could be detrimental to the operation of the power plant or the overall impact it may have on the environment. We must know the variable concerned before an evaluation of the degree of activity can be undertaken. By and large the selection of the most suitable location for such a power plant in a given coastal region will be characterized by the vector space enclosure, defined by the acceptable segments of the variables under active consideration, which is most closely identified with that pertinent to a theoretically ideal site location. Activity on some variable scales can be fairly broad without invalidating a site whereas, for others, quite strict limits will apply. Nonconformity with respect to such limits can, in practice, invalidate a site even though in all other respects conditions may be close to ideal. An obvious example will relate to critically high seismic activity. In practice then, the idealized vector space referred to above is not a homogeneous construct but rather may be said to vary in its density (if this can be taken as an appropriate metaphor to describe the acceptable degree of variation associated with the expression of particular key variables).

Without developing this conceptual model further, it is sufficient to say that it can also be applied to cases in which an allocation procedure must be developed to assign potentially competing projects into different locations. It is obvious that the conditions best suited to the siting of the nuclear power plant previously considered, with respect to a particular coastal area, will also be appropriate to other industrial operations, for example, a steel mill. There are, however, critically different considerations which relate to a steel mill: it does not pose a great risk to resident populations via potential radiation discharges; it does not require huge volumes of water as a coolant, etc. Plainly the vector space enclosure or, to simplify this concept, the relevant environmental factor intersection, will be different and hopefully suited to a separate location, removed beyond the possibility of interaction with a power plant. It must also be noted that interaction effects can also be represented as active variables and can therefore be factored into an analysis such as this. Theoretically, many developments and projects can be covered in this manner and, provided there is sufficient suitable physical space available in which to locate them, they will all be assigned to the best sites by application of the foregoing procedure. Failing this, those most suited to the available site locations will be identified on a site-by-site basis.

In the absence of specific siting problems, with what should the coastal manager be concerned? In the light of the foregoing analysis, he should be concerned with the evaluation of the dominant trends expressed by major environmental factors with respect to the coastal area under his control. Initially, investigations should be concentrated around the coastal/marine interface. However, with time, attention should be shifted to determination of the broad outline of processes which relate coastal seas to the adjacent oceans. Naturally, the invesitgators of the coastal and open seas interface will involve much heavier financial expenditures than those entailed for the investigations mounted in inshore regions.

At this point, certain fundamental notions regarding the nature of data acquisition need to be introduced. Much has been made in the past of the concept of random sampling. If one were to apply this principle blindly in the field, the actual size of the necessary data base required to adequately characterise the principle environmental trends present in any major coastal area would be excessive. In truth, most data acquisition programmes suffer from an excess of redundancy in the level of observations applied to regions that are not critical with respect to generation of a proper cost effective understanding of the action of major "design impact" environmental variables.

There are five points to be considered when setting up a properly stratified coastal zone data acquisition programme. These are:

1) the prime interest should be centred on trend identification and numerical description;

2) in order to define unidirectional trends, an absolute minimum of three observational sets are required, spread over the active region or <u>time base</u> of interest;

3) in order to be statistically robust, all observation sets must be replicated at least three times;

4) every available item of pertinent information should be used to locate the initial pattern of observation sets;

5) established patterns of observation sets should not be lightly abandoned.

If these extremely basic rules are followed, there will be very little need to talk about the kind of analytical procedures to apply to the resultant data base, nor will the matter of interpretation raise additional problems. The underlying pattern revealed by the observations will likely be clearly obvious. Where it is not, the logic of available information will suggest the next plausible steps such as by inclusion of additional observation sets. The above outline is adequate to describe the course of events which should be followed in any investigation. However, there are points which require further expansion.

(a) <u>Factor identification</u>

The question of the identification and definition of major environmental factors has not been dealt with; i.e., what characteristics of the environment are worth investigating? What factors are in fact relevant to coastal management in particular? Some of the principal factors are mentioned in Table III.2, others will undoubtedly be relevant in different locations. There are no rules for factor definition; definition is the responsibility of the project manager. This is particularly true of biological factors; generally one must look first at economically important species (commercial and recreational), nationally protected or internationally endangered species and finally at the structure of the food web supporting the previously defined "important" species. Any species or group of species through which a major energy flux takes place (i.e. coral reefs, mangroves) should likely be considered for analysis. Exhaustive lists of environmental factors to be used in comparing the effects of alternative nuclear power plant systems may be found in the U.S. Nuclear Regulatory Commission's guide for the preparation of environmental reports (1978).

(b) <u>Trend analysis</u>

In defining a trend, it is generally true that provided the sets of observations are evenly spread over the active region or time base, it is to be understood that the more data points involved the better since a sharper definition of the trend will result. If observation sets are unwittingly

Table III.2 Selection factors relevant to site identification for a coastal nuclear power plant with once-through cooling. (Note: list is not intended to be exhaustive, see references 2 and 3 for further information on these points)

Strata	Variable activity (Low = L, High = H) Favourable	Unfavourable
Marine Processes	High thermal capacity of water mass (H) i.e., deep water (H) Low water temperatures (L) Fast currents (H) Large volume of water transported past site (H) Salinity low (L)	Low thermal capacity of water mass (L) i.e., shallow water (L) High water temperatures (H) Low or zero currents (L) Low volume water transported site (L) Salinity high (H)
Marine/fresh water interface	Large volume of fresh water available (H) No river flooding (L)	No or little fresh water available (L) Heavy river flooding (H)
Aquatic/ terrestrial interface	Stable shore line (L)	Unstable shore line (H)
Geological considerations	Low or zero seismic activity (L) Solid foundation material (L)	High seismic activity (H) Loose or compressible unstable material (H)
Meteorological conditions	High wind activity (H) Prevailing winds away from direction of population centers (L) Hurricanes rare or absent (L)	Low wind activity (L) Prevailing winds towards population centers (H) Hurricane activity plentiful (H)
Biotype considerations	Little or no movement of commercial migratory fish past intake (L) Low populations of edible clams present (L) Etc.	Much activity in the movement of commercial migratory fish past intake (H) Heavy populations of edible clams present (H) Etc.

jammed together, a serious bias to the apprehension of the overall trend can result. Notwithstanding this, if a peculiarity or nonconformity with adjacent data sets is suspected, the observation points should be clustered in the appropriate region to define the issue. Recall, however, the basic rule: the clusters should be made in subsets of 3.

Replication by at least three samples for each observation set is usually mandatory unless some form of statistical control (i.e., implied prior knowledge) is to be exercised, such as is suggested by the use of covariance analysis. In general, the higher the replication factor, the more precise will be trend definition. The fundamental drawback to replication and station multiplication (see 2 above) is simply cost, both in terms of workload and time spent in collecting and evaluating the data. Both these factors translate immediately into financial terms, but heavy replication can also impose a penalty on ultimate precision by introducing the factor of boredom where technical staff are concerned.

Application of the rule of 3 (3 stations replicated each 3 times) assumes that the underlying trend exerts a significant influence with respect to the active interval, or time base, over which it is to be traced. This situation is described in statistical terminology by saying that the variance explained by the independent variable is high in comparison to the residual or unexplained variance. The lower this ratio becomes for a given number of replicates, the greater is the requirement for increased replication at each observation point chosen within the active range of the relevant independent variable.

Where hard information already exists regarding variance estimates with respect to the situation in hand, the application of standard statistical procedures will reveal the minimum number of observations necessary to detect statistically significant differences at different probability levels. Usually, however, the problem is precisely that no such information exists and that the actual cost and effort involved in establishing the base line, may, and often does, dictate a once-only survey. Here the rule of 3 should prevail.

Question local inhabitants before setting up the sampling programme. Fisherman, and those who work the sea generally, have access to vast stores of community knowledge which must be carefully evaluated by an experienced and sympathetic field scientist. After this is done, follow your own intuition when stratifying the sample base to your programme.

Always try to retain a monitoring function at at least one established station when field evidence suggests that a programme be refocussed. Never fail to completely analyse the results of field data forays between operations. Never let data stack up unreviewed from one field outing to the next.

(c) Pattern analysis

The use of pattern analysis arises naturally as a progressive complication of trend analysis. A pattern may be simply described or approximated by successive segmental trends or straight line segments. The rules governing elementary pattern analysis are contained within the considerations previously covered for trend analysis. Specific problems relating to the analysis of fine scale species-area analysis form part of a separate mathematical framework which will not be investigated at this point, concerned as I am with establishment of basic considerations. Pattern analysis and identification as a general function in coastal management is important for two basic reasons:

All time based trends are usually subject to seasonal modifications. Through the interactions of trends in space and time, pattern is established. The systematic seasonal variation of environmental variables can be represented adequately in the conceptual model previously developed once the patterns concerned have been identified.

Ecosystem representation in any coastal region is characterized by specific patterns both in time and space. These must be strongly quantified before any environmental alteration is carried out for two reasons:

(i) to predict the effects of project induced environmental trend modifications on ecosystem structure and function so that questions regarding survival likelihood can be clarified. This in turn leads to plant or project modification such that environmental harmony is achieved; i.e. no species are eliminated or suffer substantial damage;

(ii) to identify templates that can be used to underlay the assessment of subsequent deviations induced by coastal modifications.

PROCEDURAL ASSESSMENT PROBLEMS

The foregoing section has dealt with idealized procedures which many would view as necessary to begin dealing with the complexity presented to responsible parties in attempting to deal with coastal management problems. In essence, the underlying assumption presented therein was that it was indeed possible to fit developmental projects into particular slots in the coastal environment, each one suited to its particular needs and demands in such a way that minimal overall reduction in the quality of the environment would follow. Competing development projects would simply be assigned according to their interactive potentials to particular locations wherein their presence would be comfortably realized. Modifications to design and structure would be assumed in order to minimize or completely eliminate deleterious environmental impact, such modifications being dependent on the initial factor analysis whereby plant characteristics, environmental physical attributes and ecological considerations were harmonized to the benefit of all.

Unfortunately, the truth of the matter is that no such system can be found operating anywhere within the world today; it is a myth. More and more, however, a consultant or manager finds himself faced with the situation in which a specific choice to locate a plant or development scheme in a particular coastal region has already been taken, and he is asked to evaluate the impact of the proposed plan. In some cases, the location has been determined by recourse to traditional economic cost analysis with respect to raw material availability, export-import considerations, labour availability, basic energy considerations and the like. In most cases, the location will have been decided by fiat on the part of a private company, a senior administrator or a politician. Often enough, whatever the reason utilized for the choice, it will have nothing whatsoever to do with environmental considerations. If the situation poses a severe threat to the environmental integrity of the region, it is up to the consultant or coastal manager to develop the data base and information set which will point this out.

In the same manner as analysis focused on the survival capacity of a nuclear power plant in the face of predictable physical events discharged by the environment can be expected to result in removal of the project or at least its modification if destruction is foreseen, a similar response should be generated if fundamental environmental values are endangered. In principle, the same form of trend analysis has to be developed as previously described for the regional basis except that the overall study is now centred on the plant site exclusively. The critically active environmental processes which intersect the actual site must now be identified and quantified. The specific effluents to be produced by the completed plant either directly or as a by-product of construction or operation of the project, etc., must be identified and catalogued along with the geographical locations, quantities involved and their projected discharge schedules. This information now provides the basis for setting up the necessary ecological and environmental monitoring programme.

As before, such a programme should be tied fundamentally into trend analysis. In this case, maximum concentrations of pollutants or environmentally disturbing agents generally are going to be accumulated at the plant site. The influence of these factors on regional ecosystems is largely going to decrease with distance, except in the case of "sink" accumulations of radioactive materials or heavy metals or certain halogenated hydrocarbons. The task of the coastal manager, either directly or through his consultants, is then to determine the likely pathways by which pollutants and disturbing influences will express themselves in the environment. The importance of firmly establishing the principal physical trends which intersect the plant site can now be readily appreciated. The investigator must seek to establish base line data that will enable future assessment of the realized impact of the plant to be made, as well as to elucidate the nature of the resident ecology with the view to being able to predict exactly what that effect will be, prior to operation of the facility. The actual design of the survey programme utilized should benefit from construction and operation of a computer simulation which is designed to reveal the progressive influence of the plant on the adjacent environment for all important physical and chemical considerations.

Again, to use the example of a nuclear power plant with once-through cooling, such a model should show the volume and spread of the resulting thermal plume under all tidal conditions at intervals no greater than 0.5°C. Once this pattern is determined, it is a simple matter to plan a corresponding sampling programme. In general, there should be at least three stations located within the dominant axes of the plume and a further three established entirely outside the predicted influence of the plume. These should be in line with the first set and, ideally, separated from one another roughly by the same distances as are the members of the first set. This form of station disposition should also be set up with respect to the minor axes of the plume.

This arrangement will allow for prior assessment, for subsequent trend analysis with respect to the plume influence and for some degree of comparison with a pre-existing control set. Often it will not be possible to develop a model of effluent disposition prior to the establishment of the sampling programme because of financial constraints or because of lack of time. In this case, the responsible manager must establish his assessment stations by intuition and be referring to the dominant environmental trends which intersect the plant site. As before, a broad based random disposition of stations or even an evenly set out lattice work or grid of stations situated around the plant site represents needless redundancy as far as sampling effort is concerned.

Perhaps simplest and most effective design is to carry one line of stations at right angles to the coast, and another at right angles to the first, parallel to and a short distance from the shore line. These lines should involve a minimum of 6 stations in each of the 3 directions: the first three judged to be within the influence to be exerted by the plant, the second three, outside. Of course, where a primary and dominant environmental trend exists which is at variance with the above simplified model, such as would be the case where a powerful and systematic current influences the region then stations should be located according to the direction imposed by this influence and distributed according to dominant geographical demands.

As far as biological measurements are concerned, a coastal marine assessment should cover at least the following systems: phytoplankton, zooplankton, large demersal and pelagic organisms, benthic, littoral, fouling communities and periphyton or diatom communities settling on glass plates. The last two are particularly important because they are obtained from a relatively constant background (seasonal influences excepted) of the plankton and are useful as direct monitoring references (Harger et al. 1973 a, b; Harger and Nassichuk 1974). Since they are developed by the investigators themselves, such communities have known histories and are not as vulnerable to the action of unknown biological and physical influences as are naturally resident communities.

A full breakdown of the community and biological analyses required in the case of nuclear power plant construction may be found within the Regulatory Guide for the Preparation of Environmental Reports previously used by the Atomic Energy Organization in Iran (Harger and Culhane 1974) and in the equivalent U.S. Nuclear Regulatory Commission Guideline (1978). The end result of the above exercise of environmental assessment should be the production of an environmental cost benefit analysis which will endeavour to take all relevant factors into consideration with respect to the ultimate advisability of constructing the plant in the location concerned. The most difficult part of the exercise involves the monetary quantification of natural resource loss when the items concerned are not market entities. Several different approaches to this problem have been suggested (Scott 1965; Harger and Culhane 1974) yet the the actual quantification remains a challenge to individual investigators. However, it may be noted that as the world price of energy more nearly reflects its work or productivity potential, so the use of energy itself (or information produced as the result of energy degradation) may more nearly approximate a universal system of account.

The final decision regarding the advisability of establishing the plant in question then should rest on the results of the environmental cost benefit analysis which, in turn rests on the environmental and ecological assessment utilized particularly with respect to predicted losses. The firmly quantitative, rational, systematic and practical assessment of such losses is therefore of fundamental importance to the whole question of coastal management. The essence of this approach is to let the data do the arguing.

POST OPERATIONAL ASSESSMENT PROBLEMS

I have so far considered options that should be available in an ideal world. However, these are all too often nothing more than flights of academic fantasy in which the imperatives of economic development and national interest in social advancement play the decisive part. The coastal manager, in whatever form he is to be found, is normally presented with industrial projects as fully operational entities before he has the time to comment on their relevance. Either that, or he is faced with the difficult task of eliminating a plant or plants which have been guilty of polluting the surrounding seas for years but which for political reasons have been tolerated by one interest group or another. In such cases, the manager must find a way to simply show systematically that the operation concerned is generating measurable environmental and ecological damage. He must produce a systematic assessment which will support his claim that corrective measures need to be taken against the plant in question. There are two factors that he must inevitably deal with in such a situation:

(1) plant managers will usually flatly deny the existence of environmental damage;

(2) because of local conditions there is likely to be little money available to support an extensive assessment programme.

The basic objective of any investigation programme which deals with assessment of established plants is to demonstrate the presence or absence of environmental, or rather ecological, damage in association with the discharged pollutants. An inexpensive procedure admirably suited to this function consists of laying out replicate plastic or glass plates at progressive distances from the plant so that regions both within the influence of the discharged materials and outside this area are monitored by the development of either macroscopic fouling communities in the case of the plastic plates or by periphyton-diatom communities in the case of glass slides. The collecting surfaces can be placed on bricks at the lower intertidal level of the sea shore, suspended below floats or beneath piers, etc., such that the collectors are never exposed on low tides.

An essential component of this procedure consists of a physico-chemical monitoring programme from which measurements of all important characteristics of the sea water at each sample location are obtained. Factors monitored should include such items as distance from the plant, water clarity, salinity, temperature, depth (if applicable), as well as direct measurements of the principal pollutants i.e., sedimentary analysis for heavy metals (i.e. copper), analysis of heavy metals in the flesh of bivalve molluscs adjacent to the sampling locations, etc. The level of replication imposed on the sampling surfaces must be fairly high (around 120 or more per station) because of the highly variable nature of community development.

Assessment of the biological responses generated may be made at one instant or progressively over a period of time to take account of successional processes. The actual recorded data consists simply of a complete species/individual frequency list for each sampling surface. From this background, a number of measurements relating to the structure of the resultant communities can be constructed. These are usually gathered under the heading of community diversity indices. The simplest such index is merely the total number of species to be found; more complex indices such as the information theoretical index (H') take account of the relevant frequency of individual species representation by individual organisms (Pilou 1966; Harger 1973; Harger and Tustin 1973).

The basis of subsequent analysis involves the tendency for ecological communities to become simplified in the face of stress which is outside their evolutionary experience (Pilou 1966; Harger 1973). In simple terms, communities exposed to pollutants support few species in comparison to those developing under similar circumstances but having no pollution burden to face. The technique of multiple regression is then used to identify those physical and chemical factors which account for most of the observed variation along the sampling transect from the plant to a region of clean water. It will usually be found that the primary components of the pollution source are directly related to reduction in diversity.

A parallel methodology involves the establishment of healthy communities from clean water locations and their subsequent transfer into the sampling transect (which would in this case extend into the nursery area). This method measures negative community response to surrounding circumstances rather than availability of colonizing forms as tested by the first procedure. The communities resulting from either method can be further dissected and biomass determinations developed for all trophic levels present. This will result in the possibility of successive evaluations of productivity decline, or decline in trophic structure, being established with respect to background physical conditions.

The results of this form of study, properly undertaken, are definitive at all levels of structural and trophic relationships present in ecological communities, since all levels are present, even on the microscope slides. The actual time interval involved ranges from a matter of three or four days only in the case of microscope slides immersed in the Persian Gulf during summer months[12] where sea water temperatures may approach 39°C, to intervals as long as 1-3 months for temperate communities developing on plastic plates during the winter (Harger and Tustin 1973). For microscope slides subject to continual immersion in the summer, somewhere around 7-10 days is probably sufficient for adequate development of a community under non-polluted conditions. Slides placed in the intertidal region will require a longer period (Harger and Culhane 1974). For fouling communities a location such as the Persian Gulf (Harger and Tabatabaie 1976) can generate excessive growth rendering counting difficult in only 10 days during the summer. A period of approximately 2-3 weeks is probably satisfactory for most situations. It must, however, be firmly stated that since succession itself is accomplished by generally increasing community diversity (Harger 1973; Harger and Tustin 1973), it is essential that comparisons be made on the same time base. This includes comparisons made with respect to seasonal effects.

Some time must usually be spent in any particular situation in a preliminary field investigation of community response rates so that a "time slot window", so to speak, can be chosen which is sufficient to allow a significant response to have developed but not allowing so great a time since immersion that the resulting assemblage of organisms is visually chaotic due to overgrowth, etc. Since a relatively large number of communities must be scored in utilizing this procedure, it is advisable that the technicians involved do not have to strain themselves in assessing each community.

Application of this general methodology is simple, inexpensive and involves the use of a theoretically far reaching data base. If the method fails to detect any form of community degradation in association with the plant under consideration, then the industrial operation concerned poses no threat to the environment.

References

Harger, J.R.E. (1973). Succession and stability in biological communities. Part 2: Organization. Int. J. Environmental Studies. 5. 183-192.

Harger, J.R.E., Campbell, M.L., Ellison, R., Lock, N.P. and Zwarch, W. (1973a). An experimental investigation into effects of pulp mill effluent on structure of biological communities in Alberni Inlet, British Columbia. Part 1: Subtidal Communities. Int. J. Environmental Studies. 4, 269-282.

Harger, J.R.E., Campbell, M.L., Ellison, R., Lock, N.P. and Zwarch, W. (1973b). An experimental investigation into effects of pulp mill effluent on structure of biological communities in Alberni Inlet, British Columbia Part 2 : Intertidal Communities. Int. J. Environmental Studies. 5, 13-19.

Harger, J.R.E. and Culhane, F.G. (1984). Ecological cost assessement theory and practice: Environmental impact of the High Ross Dam. Int. Journal of Environmental Studies. 6, 267-280.

Harger, J.R.E. and Nassichuk, M.D. (1974). Marine intertidal community responses to Kraft pulp mill effluent. Water, Air and Soil Pollution. 3, 107-122.

Harger, J.R.E. and Tabatabaie, H. (1976). Final Report to United Nations Environment Programme covering grant (UNEP. U-17) project No. 0501-74-001. The Study of the Behaviour of Pollutants in Warm Waters. 102pp.

Harger, J.R.E. and Tustin, K. (1973). Succession and stability in biological communities. Part 1: Diversity. Int. J. Environmental Studies. 5. 117-130.

Pilou. E.C. (1966). Species diversity and pattern diversity in the study of ecological succession. J. Theoret. Biol. 10, 370-383.

Regulatory Guide for Preparation of environmental reports for nuclear power plants. Revision 1. Atomic Energy Organization of Iran, Environmental Protection Division, Nuclear Regulatory Directorate. Tehran, Iran, June 1978.

Scott, A. (1965). The valuation of game resources - some theoretical aspects. Canadian Fisheries Reports, No. 4, 27-47.

CHAPTER FOUR

BACKGROUND TO THE FIELDSITE AT BANDENGAN, JEPARA, NORTH JAVA

A) Otto Ongkosongo
National Institute of Oceanology
Jakarta
Indonesia

B) Supriharyono
University of Diponegoro
Semerang
Indonesia

Bandengan is a small bay near the University of Diponegoro's field station at Jepara in North Central Java, Indonesia (Figure 4.1). The bay is influenced by land drainage from a stream in the bay and three large rivers in the area, River Mlangga, the River Gong and the River Belakang Gunung. In the Jepara region the coastal fringing reefs are under pressure from the following activities:-

(a) Mining for dead and living coral which is used in the production of lime, construction of houses and roads, shore protection, and marks of land ownership

(b) Fishing

(c) Collection of aquarium fish and zooanthids for the aquarium trade

(d) Construction of corals for sale as souvenirs locally

(e) Boat anchorage and construction of jetties

(f) Recreational use

(g) Scientific research

(h) Sedimentation resulting from agricultural practices.

The area is also a centre for aquaculture research with the Brackish Water Aquaculture Development Centre located at Jepara focussing research activities on shrimp (Penaeus) and milkfish (Chanos chanos). Much of the coastal zone in the region is devoted to the practice of aquaculture in brackish water fish ponds (tambaks) and it has been estimated that there are 782 ha of fish ponds in the Jepara district (Padlan 1979).

(A) Geology and geomorphology of the Jepara region

The coast of the Jepara region, between the Wulan Delta and the Bay of Mlangga (Figure 4.2) can be divided into two morpho-sedimentological units, namely the low raised reef and its related genetic unit, the beach ridges (which are spread in the Northern part of the study area) and the deltaic plain in the South, which is composed chiefly of a black, clay deposit. The underlying rock produced by the Muria ancient volcano (height 1602m) is a leucite-bearing igneous rock. The volcano is of young Pleistocene age and is currently an extinct, heavily dissected volcano inland drained by two main rivers the Northern and Southern Gelis.

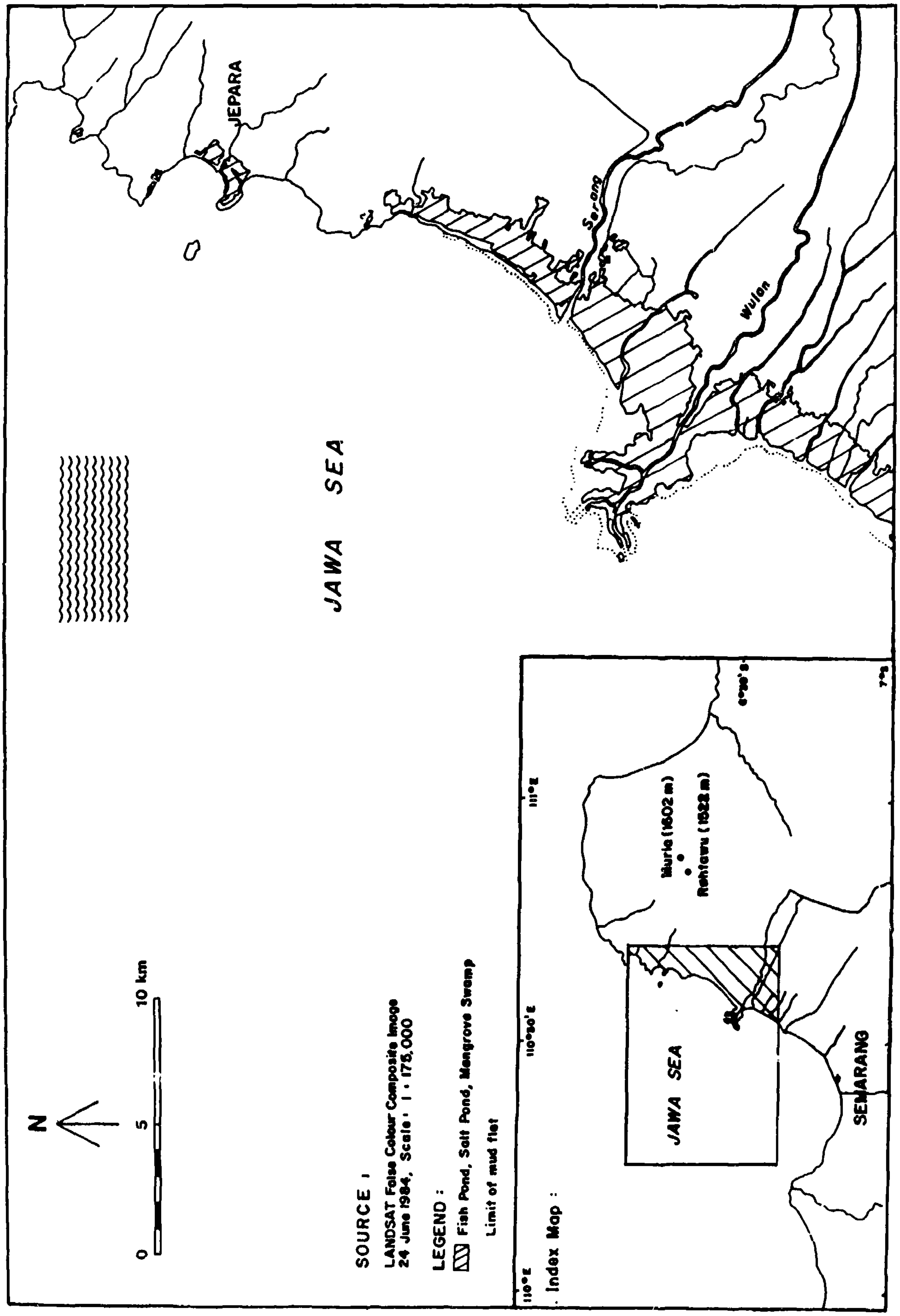


FIGURE 4.1 LOCATION OF THE STUDY AREA AT JERAPA SHOWING THE EXTENT OF FISH PONDS, SALT PONDS AND MANGROVE SWAMPS. INSET MAP SHOWS THE LOCATION OF THE SITE WITH RESPECT TO SEMARANG ON THE NORTH COAST OF JAVA

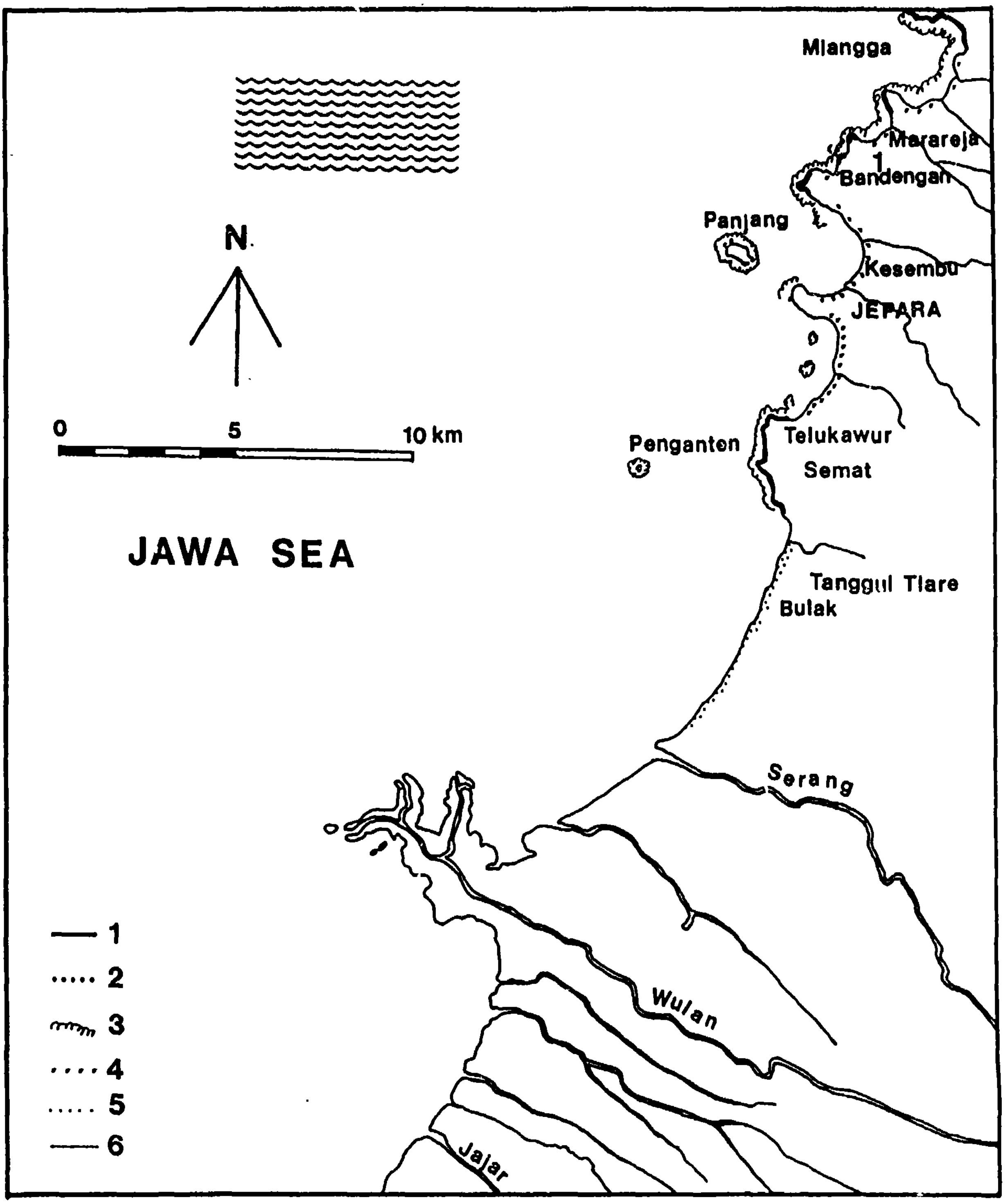


FIGURE 4.2 GEOMORPHOLOGICAL FEATURES OF THE COASTAL REGION AT JEPARA

1 = wave-cut platform of the raised reef
2 = raised massive corals
3 = living coral reef
4 = bioclastic beach ridges
5 = chenier on top of the muddy coast
6 = muddy coast with small pockets of beach ridges

Coastal morphology of the Jepara region

The coastal plain in the region of Jepara is relatively narrow, widening towards the south. In the north the coast consists of small embayments with their promontories formed by low raised reef as cores. The promontories are generally characterised by low flat strata composed of a raised middle Holocene reef on the bottom, overlaid by corralline breccia, mainly composed of Acropora shingle, from reworked sediments. Because of the present lower sea level the coastline is a very low cliff, about 1-2.5m high; the reef being formed on volcanic rocks at the foot of the ancient Muria volcano.

At Bandengan, on top of the raised reef, there are three layers of coral shingle intercalated with two paleosoil lines and covered by a layer of black sediment. This feature is found towards the South, as far as Semat, although there are minor variations in the number and thickness of the shingle layers and the height of the ancient wave cut platform, above sea level. At certain sites the coast is laterally intersepted by lowlands formed by muds which were originally dominated by mangrove forest. Currently, most of this vegetation has been deforested and the land is used as fishponds. At other sites the coast is formed of beach ridges composed of sand (e.g. S.W. Jepara and Bandengan) derived from the erosion of fossil and recent coral reefs and the shells of molluscs.

The heights of the elevated reefs range from 0.5-1.0m above the present high tide level. The elevated reef was laterally levelled forming a wave cut platform. During storms the eroded fragments accumulated on this platform, forming layers of shingle. Consecutive storms produced layer upon layer of shingle, with decreasing wave energy resulting in gradually finer grain sizes of sediment in the uppermost layers. Layers may be separated by black soils, produced during weathering processes, with upper layers overtoppped by gravels and sand.

The present sea level and wave activity is currently producing a wave cut platform which may be up to 200m wide and which is best exposed south of Jepara at Telukawur. At Jepara the tidal range is approximately 0.8m (Figure 4.3) while in Semarang it is about 1.2m. The tides are mixed with a predominant diurnal pattern.

C^{14} dating of the shells and corals of the elevated reefs at Jepara reported by Thommeret and Thommeret (1978) reveal ages of 4950 + 90 years BP at 1.27m above present sea level to 3650 + 80 years BP for a sample 2.47m above present sea level (Table IV.1). Such results suggest that there was a rise in sealevel of about 1.2m from about 4950 BP - 3650 BP.

The coastline in the region has shown some major changes over time. Although some sectors of the coastline are accreting, particularly to the south around river mouths, other areas in the north are clearly eroding.

One reason for the major changes observed in the coastline has been the building of the Wulan canal in the southern part of the region, in 1982. Since this date most of the natural drainage systems have been directed towards this canal. The result has been an actively growing delta with increased seidmentation around the river mouth. (Figure 4.4). The accretion rates of the delta between 1911 and 1944 was 105 m per annum. Between 1944-1981 the western mouth eroded at a rate of 9:5m per annum but the delta

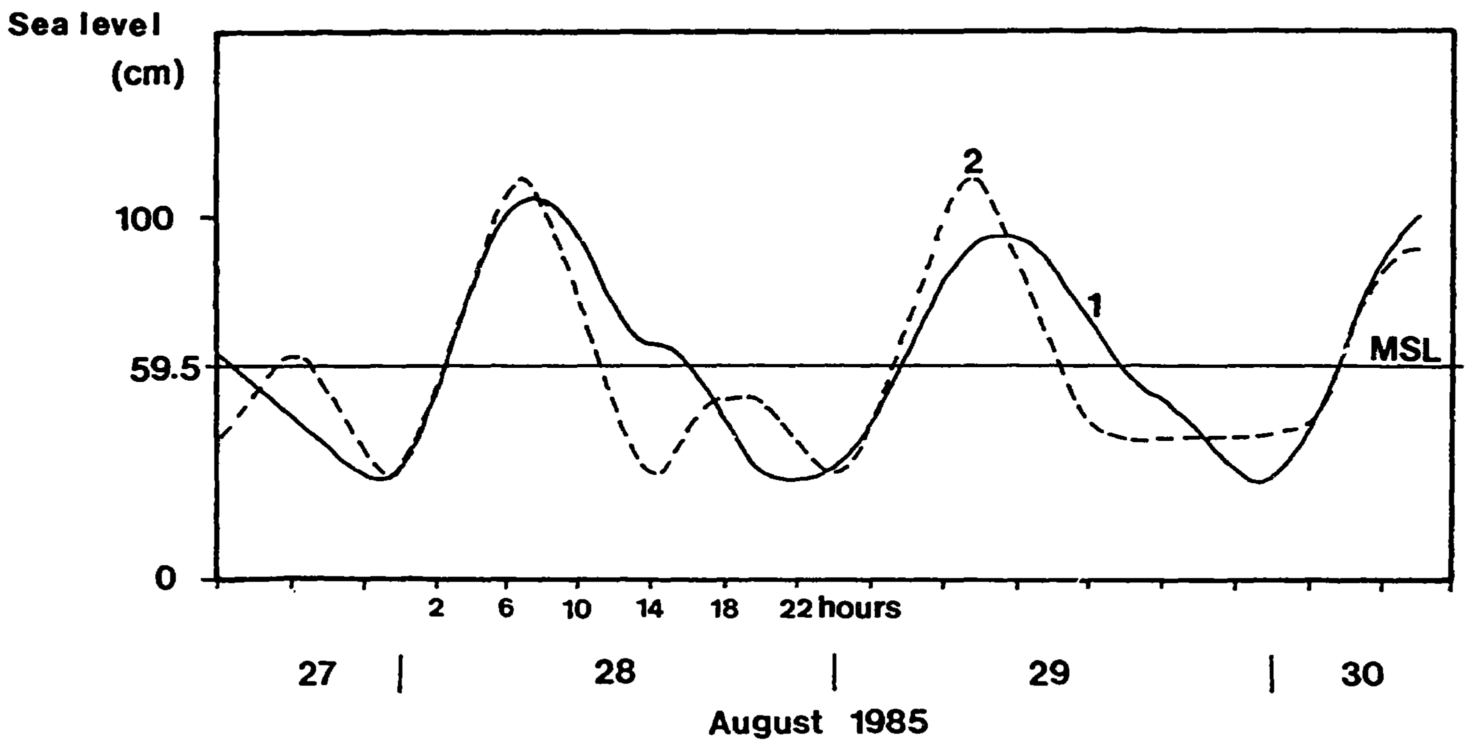


FIGURE 4.3 EXAMPLE OF THE TIDAL CURVE AT JEPARA SHOWING A DOMINANT DIURNAL CHARACTER FOR 28th and 29th AUGUST 1985

1 Tidal curve for Jepara
2 Predicted tidal curve for Semarang
(after Janhidros 1985)

MSL mean sea level

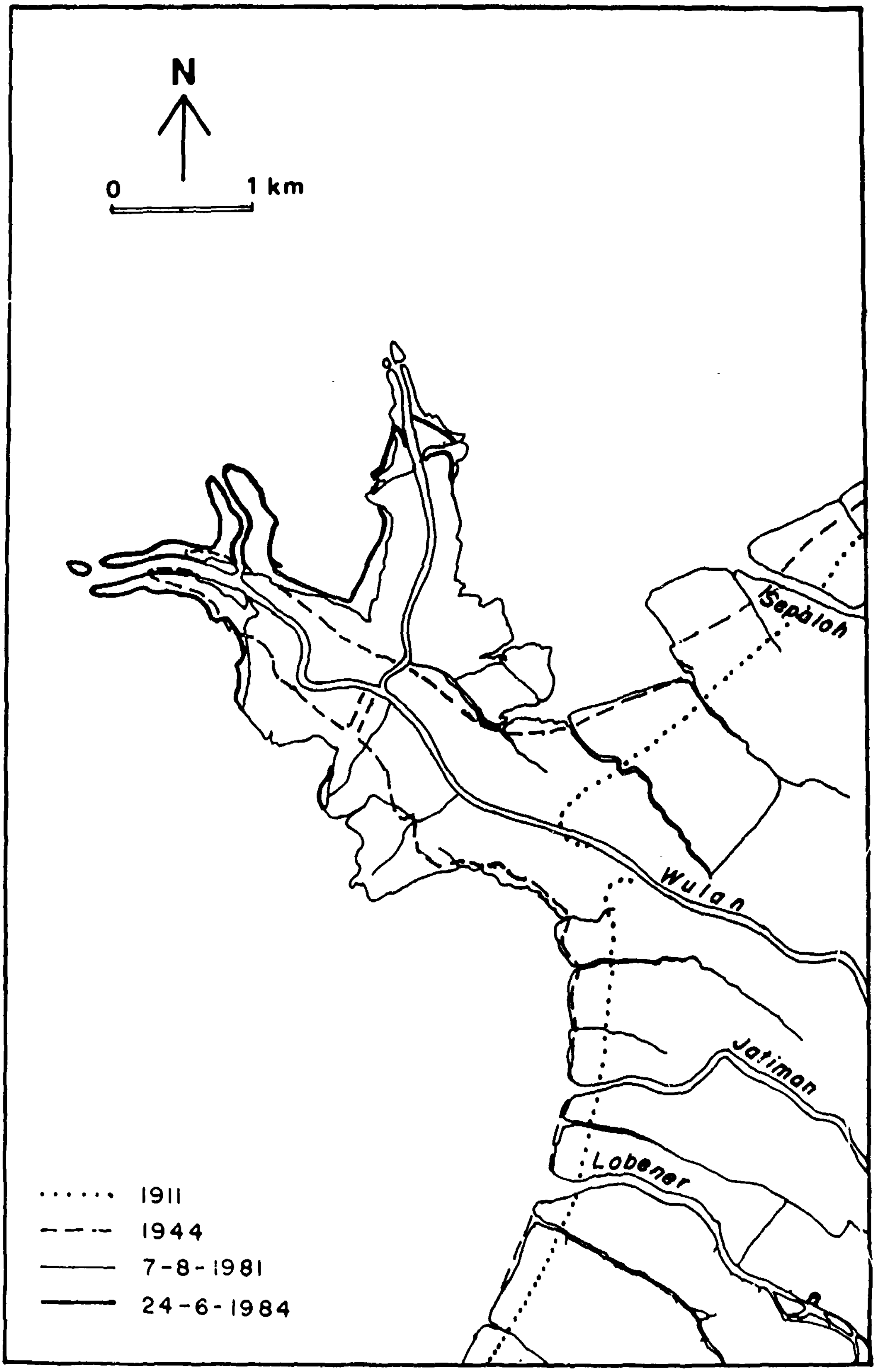


FIGURE 4.4 THE EVOLUTION OF THE WULAN DELTA FROM 1911-1984

formed protruding land to the north at an annual rate of 60m. From 1981-1984

Table IV.1. Radiocarbon dates of shells and corals from coastal low cliffs in Jepara. (THOMMERET and THOMMERET 1978)

Notes: Ages are not corrected for ^{13}C fractionation

No	Laboratory Number	Height above present sea level (m)	Material	^{14}C AGE (Year BP)
1	MC - 1158	2.47	Cardidae	3650±80
2	MC - 1157	2.37	Madreporaria	3780±80
3	MC - 1156	2.17	Madreporaria	3985±80
4	MC - 1155	1.95	Madreporaria	4460±80
5	MC - 1154	1.67	Madreporaria	4350±80
6	MC - 1153	1.30	Cerithium	3690±80
7	MC - 1200	1.30	Cardium enode	4645±80
8	MC - 1152	1.27	Coral (base)	4950±90

a further 432m per annum of land was accreted on the western outlet. Between 1911 and 1944 the new delta gained 297 ha and from 1944-1972 a further 385 ha, including beach ridge systems and a seaward margin adopted for brackish water fishponds (Bird and Ongkosongo 1980). The relatively fast growth of this protruding land has been a major influence on the ocean wave pattern approaching the adjacent coastline. The delta acts as a giant jetty which alternately stimulates coastal erosion in the up-drift zone (north) and accretion in the down-drift zone (south).

The windrose diagram, derived from data collected at Semarang Airport, suggests that the prevailing and predominant waves come from the north and north west, which would produce a severe erosion problem on the north and accretion on the northern tip of the delta, in the south. Villages in the northern region have experienced considerable erosion with much of Bulak (see Figure 4.1) now eroded away and Tanggul Tlare, originally 0.5km away from the coast, now located directly on the coast. The average erosion rate in this region is estimated to be 4-6m per annum while further north at Semat an erosion rate of 10.4m/annum has been described by Tsuchiya et al (1976).

Mining of coral from living and fossil reefs is clearly of concern to the local government since reefs are recognised as being critical to preserving the coastline by abrosrbing the energy of approaching waves. On this coast the direct effect of mining coral at Penganten Island (Visscher or Bokor Island) has been deomonstrated in the severe erosion, not only of the leeward side of the island itself but also in coastal erosion of the mainland at Semat, Tanggul Tlare and Bulak. To reduce coastal erosion the local government (Bupati) in 1982 placed a ban on limestone quarrying in Bandengan but people still violate this order.

(B) Biology of coral reefs at Bandengan, Jepara

The status of living reefs at Bandengan is clearly important, particularly in view of the severe erosion of this coastline. Recent research has been carried out on the reef in this bay, to assess the seasonal effects of sedimentation on reef corals. Four permanent transects have been established at sites, A, B, C and D, since April 1984. (Figure 4.5).

The site is characterised by fringing reef (Figure 4.6) which is affected by land drainage from a stream in the bay and three large rivers in the area, which drain agricultural land. During the wet season, especially after heavy rain, the bay receives much sediment. The mean sedimentation rate recorded is about 66.8 mg/cm^2 day, which is significantly higher than that recorded during the dry season (13.0 $mg/cm^2/day$).

Living coral covers about 27% of the reef at all sites with dead coral measuring approximately 30%. Living coral cover is highest at site A, on the south side of the bay, with reduced coral cover at sites B, C and D.

The living coral cover in the Bay consists of at least 22 genera with more than 45 species of corals. Faviid corals dominate the reef (38% total coral cover) followed by *Montipora* spp. (21% total coral cover); *Porites* spp. (20% total coral cover) and *Acropora* spp. (8% total coral cover). Genera recorded at each site in the bay are shown in Table IV.2.

The shallow water reef community at Bandengan is typical of other Indo. Pacific reefs receiving high sedimentation and subject to the 'stresses' associated with a shallow water existence. Similar communities, dominated by faviid corals have been recorded at Phuket Thailand (Brown and Holley 1984); where sedimentation levels are high and corals are exposed to aerial exposure for at least part of the day. Live coral cover on these reefs in Thailand ranges from 20-30%; the values obtained at Bandengan fall within this range. The diversity of corals at Bandengan is slightly higher than that recorded at Phuket (22 genera and 45 species at Bandengan cf 15 genera and 30 species at Phuket) - the reduced diversity at Phuket being likely attributed to the more rigourous conditions of intertidal life compared to the more or less complete submergence of reef flat corals at Bandengan.

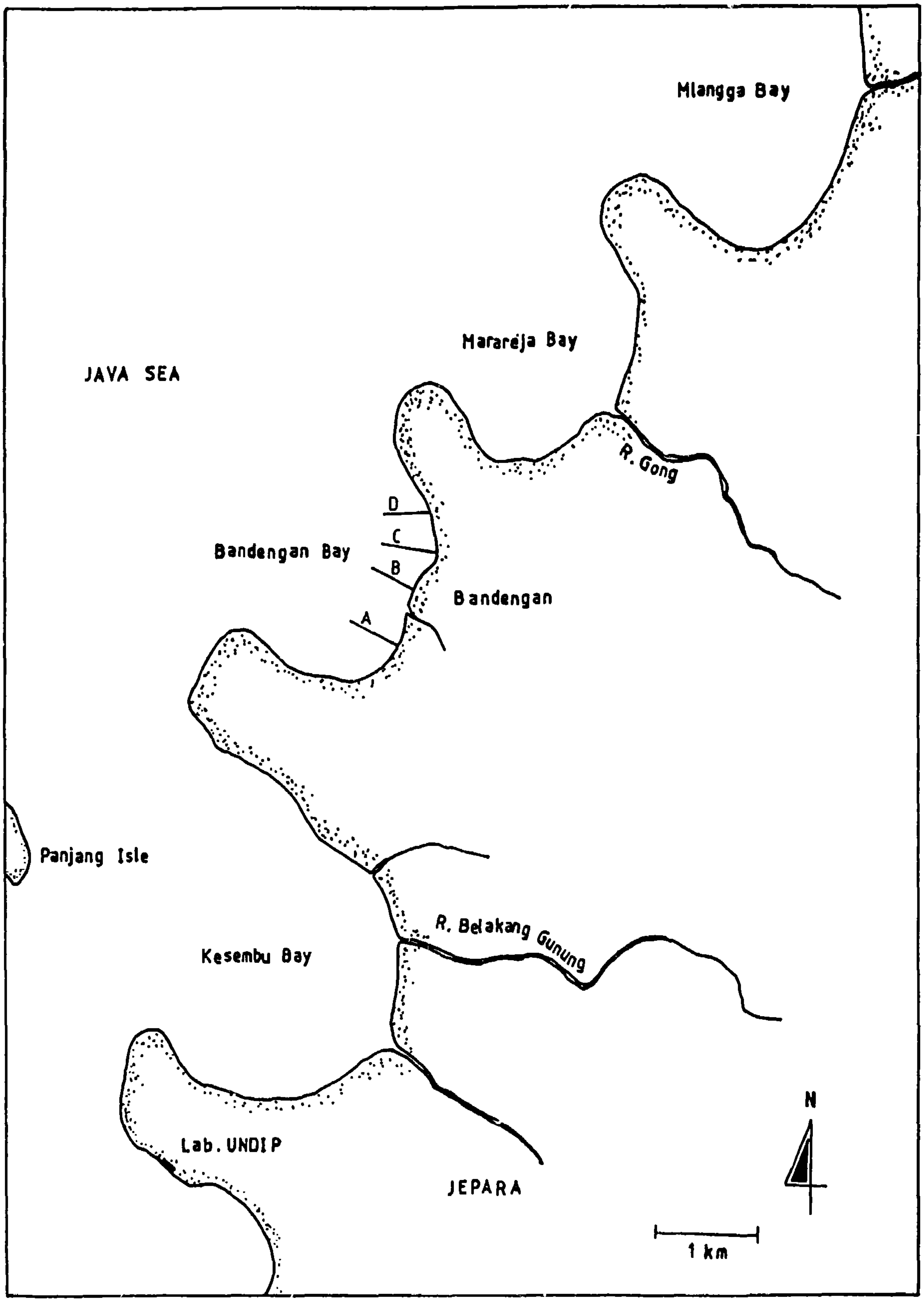


FIGURE 4.5 MAP SHOWING LOCATION OF TRANSECTS A, B, C, and D IN BANGENGAN BAY, NORTH JAVA

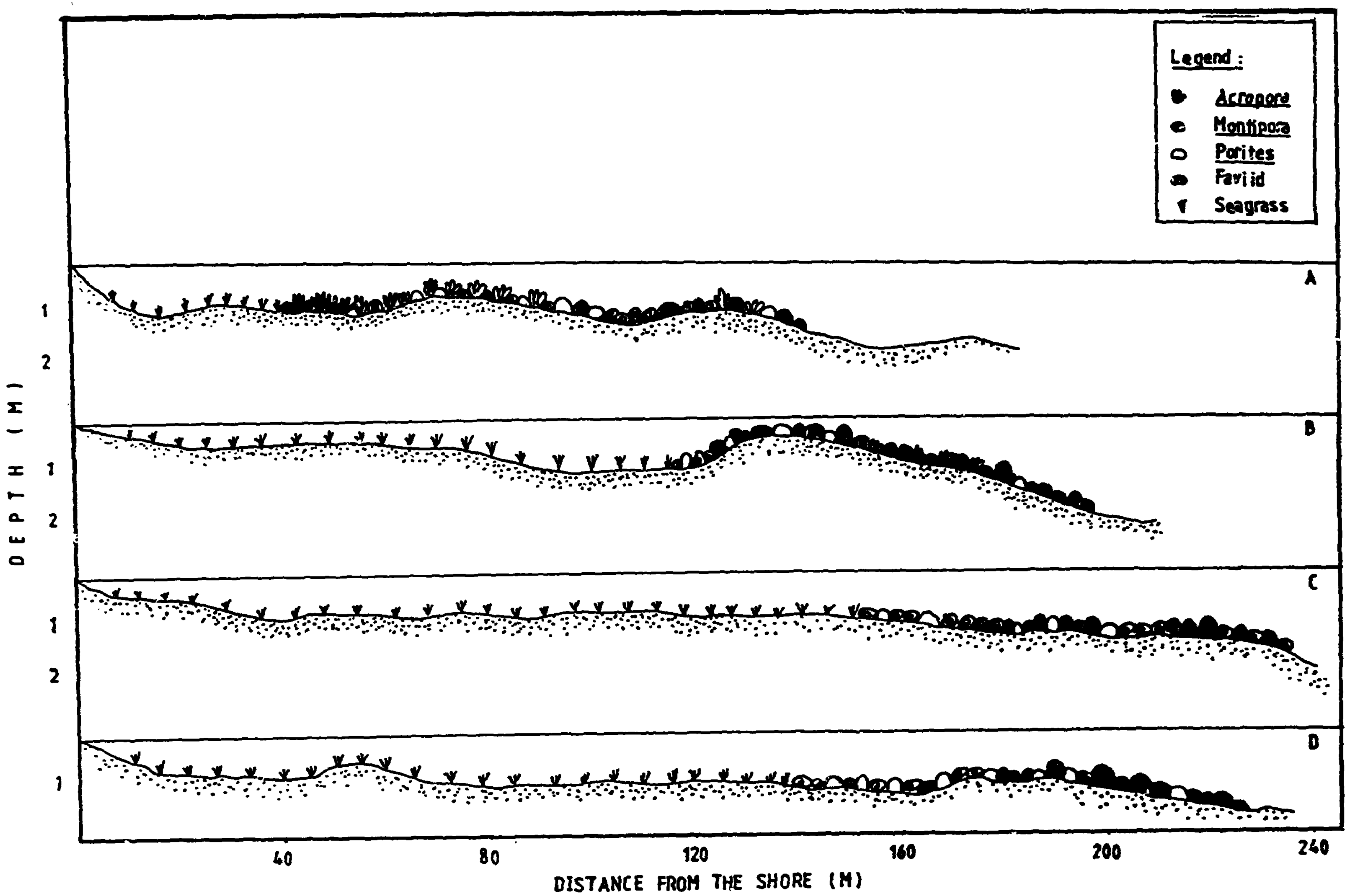


FIGURE 4.6 PROFILES OF THE FRINGING REEF AT TRANSECTS A, B, C, and D IN BANDENGAN BAY, NORTH JAVA

Table IV.2. Coral genera recorded at sites A, B, C and D in Bandengan Bay, North Java.

GENUS	SITE A	SITE B	SITE C	SITE D
Acropora	X	X	X	X
Montipora	X	X	X	X
Porites	X	X	X	X
FAVIID				
Favia	X	X	X	X
Favites	X	X	X	X
Goniastrea	X	X	X	X
Platygyra	x	X	X	X
Hydnophora	X	X	X	X
Montastrea	X	X	X	X
Leptastrea	X	X	X	X
Cyphastrea	X	X	X	X
OTHERS				
Goniopora	X			
Galaxea	X	X	X	X
Symphyllia	X	X	X	
Echinophyllia	X	X	X	
Pectinia	X			
Leptoseris			X	X
Oulastrea	X			
Pachyseris		X		
Merulina		X		
Stylophora			X	
Pavona	X	X	X	X

References

Bird, E.C.F. & Ongkosongo, O.S.R. (1980). Environmental changes on the coasts of Indonesia. United Nations Univ. Tokyo 52pp.

Brown, B.E. & Holley, M.C. (1984). Coral assemblages of intertidal reef flats at Ko Phuket: Thailand. Phuket Mar. Biol. Centre Res. Bull. 30, 1-10.

Padlan, P.G. (1979). Improvement of milkfish pond production in Jepara, Central Java, Indonesia. FAO, INS/72/003/5 Rome. 49pp.

Thommeret, T. & Thommeret, Y. (1978). ^{14}C datings of some Holocene sea levels on the North coast of the island of Java (Indonesia). Mod. Quartenary Res. S.E. Asia, 4, 51-56.

Tsuchiya, Y., Yahya, M. & Syamsudin (1976). On the Kedung Semat beach, Central Java with special reference to beach erosion problems. Inst. Hydr. Eng. Bandung 44p.

CHAPTER FIVE

PROJECTS ON 'ASSESSING CHANGES ON CORAL REEFS'

A number of projects were offered to participants during the first phase of the UNESCO workshop. Each project was designed for three to four participants, with 2 days allocated to each exercise. Given a five day stay at Jepara this schedule allowed participation in two projects, with a final day for data assessment, writing up and oral presentations of the work. Table V.1 shows the projects offered; four of the projects presented are described below.

Projects 1 and 2 - Measuring growth in branching corals (e.g. *Acropora*)

It is well known that there is considerable variation inherent in coral growth measurements (Buddemeier and Kinzie 1976). Some of this variation may be attributed to the position of the measured growth on the coral colony, since apical branches may calcify 2-3 times more rapidly than lateral branches. In addition, after alizarin staining coral branch tips may divide producing two apical polyps. These exercises attempt to assess the variability that may be encountered in coral growth measurements in one coral colony.

Summary of methods

Using the field site previously described in Chapter 4 at Bandengan, five colonies of *Acropora aspera* were stained on the reef flat with alizarin red by placing a polythene bag, full of sea water, over each individual colony. When the bag was in place, the stain (100mg of powdered alizarin red secured in the corner of the bag, 45 x 30cm in size) was released. The dye was allowed to diffuse into the seawater surrounding the colony, after sealing the base of the colony within the polythene bag with an elastic band. The stain was left over the coral for eight hours before removal of the plastic bag and tagging of the coral for subsequent relocation. The corals should be allowed to grow for one month. [In the present exercise all participants had an opportunity to stain corals in the field: subsequent analysis of stained material was carried out on material collected by participants in the field, but stained 4 weeks prior to the beginning of the workshop]. The corals were collected and handled very carefully since the newly grown tips are very fragile. The skeletons were washed in 2% sodium hypochlorite (bleach solution); rinsed in fresh water and then air dried.

In project 1 laboratory measurements of linear extension were carried out on unbranched coral tips sampled from the apex, the lateral sides and base of the colony. The length of white skeleton beyond the marker line of stain on each branch was measured using a binocular microscope fitted with an ocular micrometer. Using the same tips, the portion of white skeleton accreted since deposition of the stain, was removed using a fine hacksaw blade. Each portion was weighed to the nearest 0.01g on an electronic balance.

Project 2 involved a comparison of 'growth' of branched and unbranched coral tips from the apex of a colony. Measurements of linear extension and weight of $CaCO_3$ accreted were carried out as described above. In all cases ten measurements of each parameter were made.

Table V.1. Titles of projects used to assess changes over time on coral reefs

TITLE	METHODS INVOLVED
1. Measuring growth in branching corals e.g. Acropora	Comparison of growth (linear extension and weight of $CaCO_3$ accreted) of coral tips taken from different parts of the colony after alizarin staining
2. Measuring growth in branching corals e.g. Acropora	Comparison of growth (linear extension and weight of $CaCO_3$ accreted) of branching and non-branching coral tips after alizarin staining
3. Measuring growth in massive corals e.g. Cyphastrea serailia; Porites lutea	X ray densitometry and alizarin staining
4. Fluorescent banding in massive corals e.g. Cyphastrea serailia; Porites lutea	Comparison of X ray densitometry and fluorescent banding
5. Coral chronology and chemistry of annual bands in massive corals - possible indicators of pollution?	Measurement of phosphorus content in annual bands of the skeleton of Cyphastrea serailia
6. Coral reefs - indicators of sea level changes?	Surveillance and levelling of corals, both living and dead

Results

Results of the two experiments are summarised in Table V.2.

Table V.2. 'Growth' of Acropora aspera tips (mean values given ± standard deviation, n = 10).

(a) Tips sampled from the apex, lateral sides and base of colony

Position on Colony	Linear Extension (mm)	Wt. $CaCO_3$ accreted (mg)
Apex	4.7 ± 1.6	12.50 ± 2.6
Lateral sides	2.7 ± 0.5	7.46 ± 0.3
Base	1.4 ± 0.3	4.51 ± 1.9

(b) Branched coral tips compared with unbranched coral tips

	Linear Extension (mm)	Wt. $CaCO_3$ accreted (mg)
Branched tips	3.4 ± 1.06	4.68 ± 2.11
Unbranched tips	4.7 ± 1.13	12.10 ± 4.57

Analysis of various (ANOVA) and LSR (least significant range) tests show that there is a highly significant difference ($p<0.01$) between linear extension and weight of calcium carbonate accreted in tips from the apex, lateral sides and base of the colony, with most rapid growth shown by those tips at the apex.

In addition, significantly higher growth values ($p<0.5$) were obtained for apical tips which did not branch compared with branching tips from the apex of the colony.

It was concluded that for accuracy of measurement only unbranched apical tips of Acropora should be used in any growth measurement exercise.

Project 3. Coral chronology - measuring growth in massive corals e.g. Cyphastrea serailia and Porites lutea using X ray densitometry and alizarin staining

It is well known that X radiographs of sections of massive corals reveal a density banding pattern (Knutson et al. 1972) and it has generally been assumed that one dense band and less dense band are equivalent together to one year's growth. There has been much controversy over the factors controlling deposition of dense bands and light, temperature and reproduction have been described as critical controls (Wellington and Glynn 1983). Using both Porites lutea and Cyphastrea serailia from Bandengan this exercise attempts to determine the timing of dense band production at this site.

Summary of methods

Alizarin staining of massive corals used in this study was carried out in March 1984 and again in February 1985. Corals were collected from the field in April 1985 and after air drying were sectioned in the laboratory to produce a thin slab (8mm thick) along the axis of corallite growth. Slabs were placed on X ray film (Kodak AA) and exposed to an X ray source of 30kv for 0.8 seconds. Exposed films were processed and prints made available for growth rate analysis. The position of the alizarin stain was noted and the growth increment achieved between March 1985 - April 1985 measured. The type of banding pattern (i.e. dense -> less dense or vice versa) deposited between March 1984 and February 1985 was noted.

Results

A typical X radiograph from the massive coral Cyphastrea serailia is shown in Figure 5.1 with a distinct banding pattern. In this Figure the position of an alizarin stain deposited in this coral skeleton during March 1984 is shown. The position of the stain suggests that it is likely that one dense and one less dense band are put down in the skeleton per year. It is also apparent, in this coral from Bandengan, that the dense band is deposited during the wet season (November-April) while the less dense band is deposited during the dry season (May-October). Approximately 5mm of linear extension took place in this specimen during 1984-1985. Supriharyono (in prep.) estimates the annual growth rate of this species at Bandengan to be 4.68 ± 0.19 mmy^{-1}.

Project 5. Coral chronology and chemistry of massive corals - an indication of pollution of surrounding waters? Measurement of phosphorus content of annual bands in the skeletons of Cyphastrea serailia and Porites lutea

It has been suggested that corals may act as chemical indicators of surrounding environmental conditions (Barnard et al. 1974; Dodge et al. 1984) though the evidence is not always clear. A feature of the coral skeleton which should aid interpretation of the environmental record is the presence of annual density bands. By sectioning samples of the annual bands and analysing for phosphorus concentrations, it may be possible to obtain some estimate of the environmental history of the coral.

Summary of methods

Using either a diamond bit dentist drill or a junior hacksaw and an X radiograph as a guide, samples of one year's growth of skeleton were sectioned for phosphorus analysis. A known weight of the sample skeleton (0.2g) was heated at 600°C for at least 12 hours in a muffle furnace. After cooling the residue was absorbed in 11ml 4.5% HCl by boiling to near dryness, the remaining solution then being made up to 20ml and the phosphorus concentration measured by standard methods (Strickland and Parsons 1972). A necessary modification of these methods is the allowance of an extended development time of one hour because the molybdenum blue reaction is slowed by the presence of acid. The phosphorus so analysed is described as 'total' phosphorus.

FIGURE 5.1 X RADIOGRAPH OF SECTION OF CYPHASTREA SERAILIA FROM BANDENGAN. THE DARKLINE SHOWS THE POSITION OF AN ALIZARIN STAIN MARKER DEPOSITED IN MARCH 1984. THE CORAL WAS SACRIFICED IN MARCH 1985

Results

Although time available for participants working on this project only allowed analysis of one sample, results are presented for the period 1970-1984 (after Supriharyono, in prep.). Figure 5.2 shows the concentrations of phosphorus in skeletons of both Cyphastrea seraillia and Porites lutea from Bandengan. Values range from 0.32 - 0.60mg atom total p-PO_4 per g dry wt. of coral skeleton with little apparent variation over time. Such values are much lower than those recorded by Dodge et al. (1984) for the Caribbean corals Montastrea annularis and Diploria stringosa from sewage polluted areas.

Although sewage pollution was not suspected in Bandengan Bay, it has been suggested that seawater phosphorus concentrations may have been enhanced by run off from agricultural land and local shrimp hatcheries. If this was the case then it certainly did not appear to be reflected in the chemistry of the coral skeletons analysed.

References

Barnard, L.A., MacIntyre, I.G. and Pierce, J.W. (1974). Possible environmental index in tropical reef corals. Nature 252, 219-220.

Buddemeier, R.W. and Kinzie, R.A. (1976). Coral growth. Oceanog. Mar. Biol. Ann. Rev. 14, 183-225.

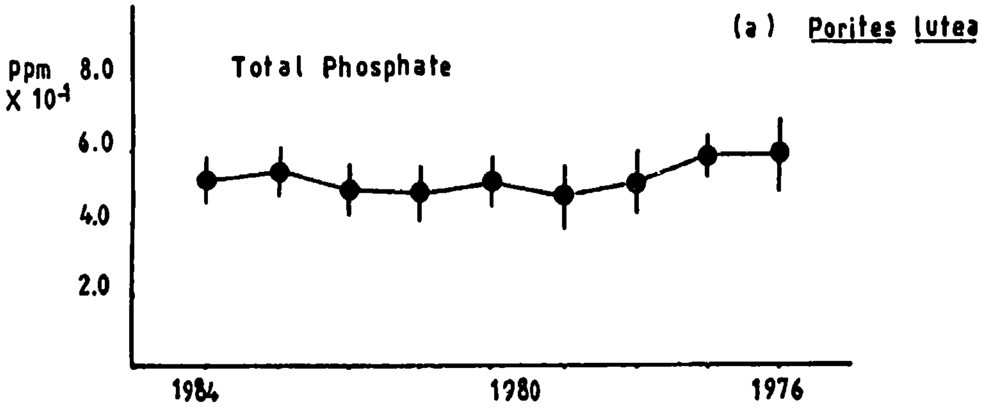
Dodge, R.E., Jickells, T.D., Knap, A.H., Boyd, S. and Bak, R.P.M. (1984). Reef building coral skeletons as chemical pollution (phosphorus) indicators. Mar. Poll. Bull. 15, 178-187.

Knutson, D.W., Buddemeier, R.W. and Smith, S.V. (1972). Coral chronometers: seasonal growth bands in reef corals. Sciences N.Y. 177, 270-272.

Strickland and Parsons (1972). A practical handbook of seawater analysis. Bull. Fish. Res. Bd. Can. 167, 311p.

Supriharyono. The effects of sedimentation on a fringing reef in North Java. PhD thesis University of Newcastle upon Tyne, in prep.

Wellington, G.M. and Glynn, P.W. (1983). Environmental influences on skeletal banding in (Panama) corals. Coral Reefs 1, 215-222.



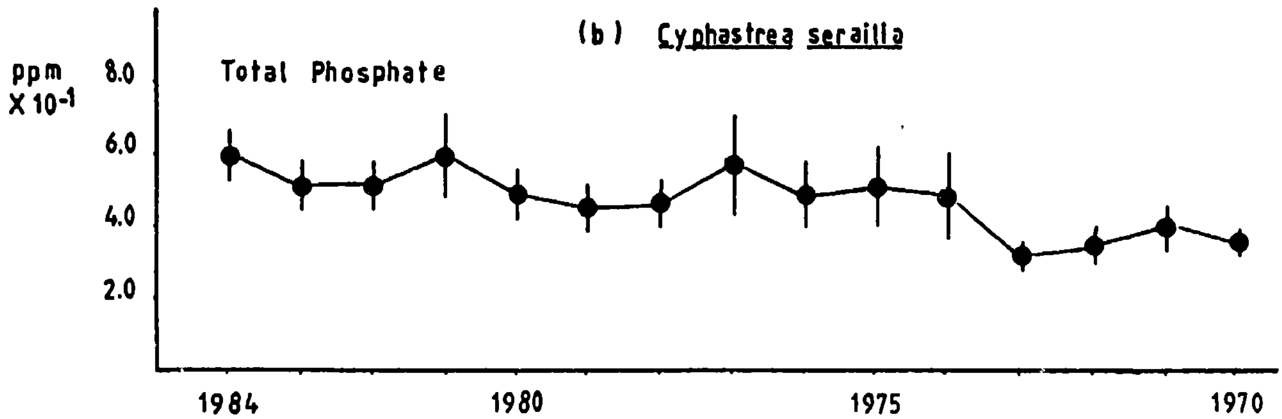


FIGURE 5.2 TOTAL PHOSPHORUS CONCENTRATIONS MEASURED IN CORAL SKELETONS OVER TIME :

(a) Porites lutea
(b) Cyphastrea serailia

Total phosphorus concentrations measured in coral skeletons over time :

CHAPTER SIX

BACKGROUND TO THE STUDY SITES IN THE BAY OF JAKARTA AND KEPULAUAN SERIBU

Otto S.R. Ongkosongo and Sukarno
National Institute of Oceanology (LON)
LIPI, Jakarta, Indonesia

Introduction

The Kepulauan Seribu (or Thousand Islands) and their surrounding coral reefs are located NNW of Jakarta, the capital of Indonesia. Together with islands within the Bay of Jakarta they form a chain of offshore islands stretching some 80km in a NNW - SSE direction and 30km from east to west between 5°47' latitude south and 5°24' latitude south and 106°23' longitude east and 106°37' longitude east (Figure 6:1). In all they consist of 108 small islands which are under the administrative authority of a special province of Jakarta. Table VI.1 summarises the alternative names of the islands in the Bay of Jakarta used in the literature published this century. In all cases (apart from Sakit which has been renamed Bidadari) Indonesian names for the islands will be used in this report.

Since the scattered, dotted reefs are very near to the country's capital, it is not surprising that they have received more research attention than any other of the nation's reefs. Papers on the geomorphology of the islands and biology of their reefs include those of Sluiter (1889); Keunen (1933) Verwey (1931 a and b, 1934): Umbgrove (1928 a and b; 1929 a, b and c; 1939; 1947; 1949); Verstappen (1952, 1953 a and b; 1954; 1968; 1977, 1983); Scrutton (1976; 1978); Sukarno (1977 a and b), Syarani (1983), Brown et al (1983, 1985) and Ongkosongo (1984).

Origin of the islands and their reefs

The history of the region has been reviewed by Umbgrove (1929b) who describes Molengraaff's view of the genesis of the group of islands (Molengraaf 1922). It is supposed that the submarine shelf in the Java Sea was almost entirely above sea level during the Pleistocene low sea level. Towards the end of the Pleistocene, on the melting of the ice caps, the extensive flat land was flooded and changed from a peneplain into a submarine shelf. It is estimated that sea level approximately 17,000 BP was about 120m below the present level (Morner 1982). The land area that formerly occupied the Java Sea is reported to have contained a large river drainage system which is now located in the floor of the sea, as a result of submergence of the region (Figure 6.2). As the area flooded there was an accumulation of transported river silt on the floor of the Java Sea, with the result that the present sea floor is made up of predominantly fine sediments.

From such a description it is clear that coral reefs in the region cannot have arisen earlier than by the end of the Pleistocene (i.e. 12,000 BP). The edges of the Pleistocene land were, however, apparently favourable places for the development of coral reefs during the Pleistocene.

Molengraaff (1922) supposed that some of the Kepulauan Seribu already existed as fringing reefs during the Pleistocene. With the submergence of the

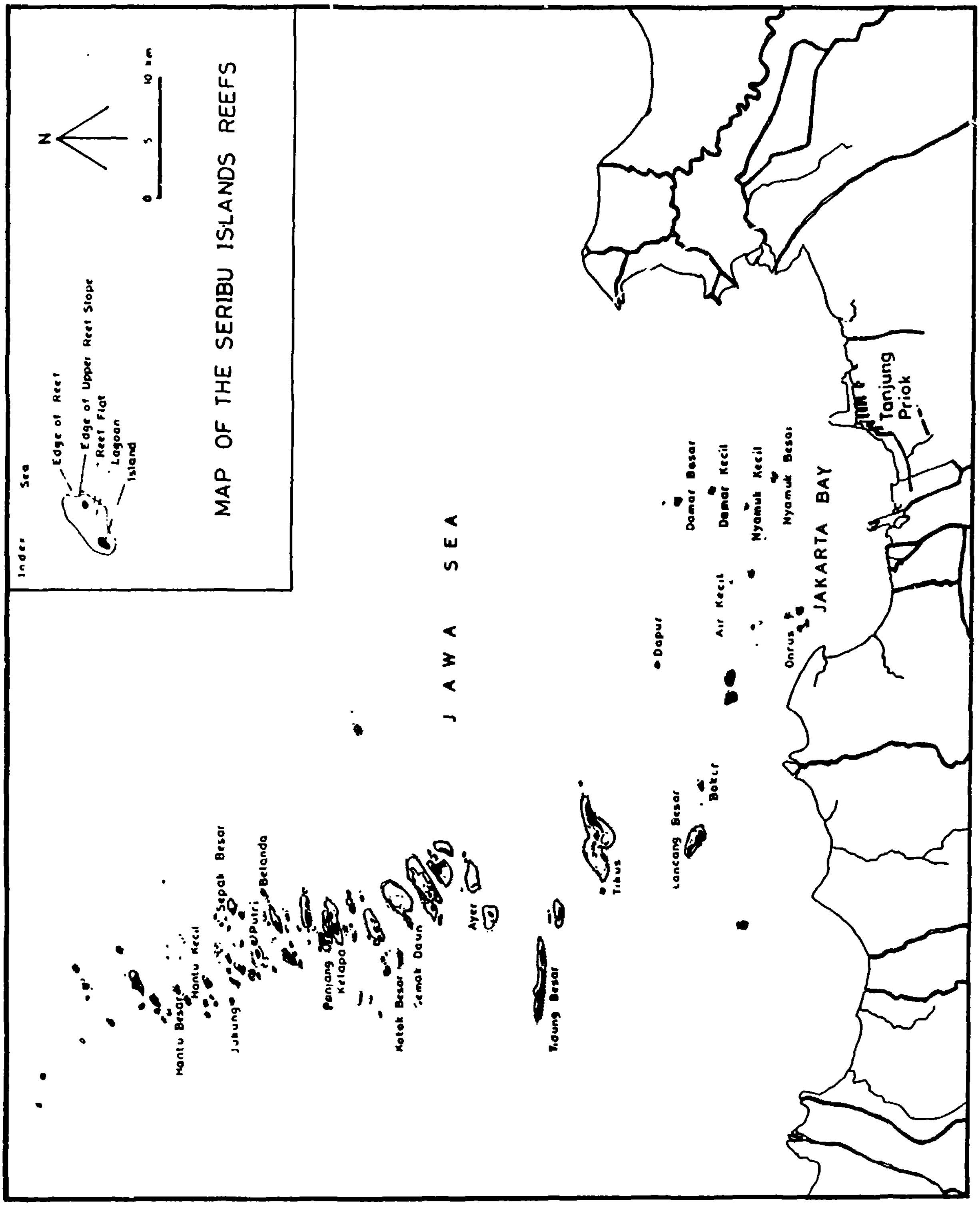


FIGURE 6.1 MAP SHOWING LOCATION OF THE ISLANDS IN THE BAY OF JAKARTA AND THE KEPULAUAN SERIBU (OR THOUSAND ISLANDS). INSET SHOWS THE SYMBOLS KEY USED FOR EACH ISLAND

Table VI.1 Alternative names of coral islands in Jakarta Bay

Dutch Name	Indonesian Name	Recent or alternative Name
Leiden	Nyamuk Besar	Nirwana
Enkhuizen	Nyamuk Kecil	
Alkmaaar	Damar Kecil	Monyet
Edam	Damar Besar	
Haarlem	Air Kecil	Lusi
Hoorn	Air Besar	
Monikedam	Air Sedang	
Purmerend	Sakit	Bidadari
Kuiper	Cipir	Kahyangan
Onrust	Kapal	
Kerkhof	Kelor	
Rotterdam	Ubi Besar	
Schiedam	Ubi Kecil	
Amsterdam	Untung Jawa	
Middleburg	Rambut	
Duifjes	Dapur	
Agenieten	Pari	

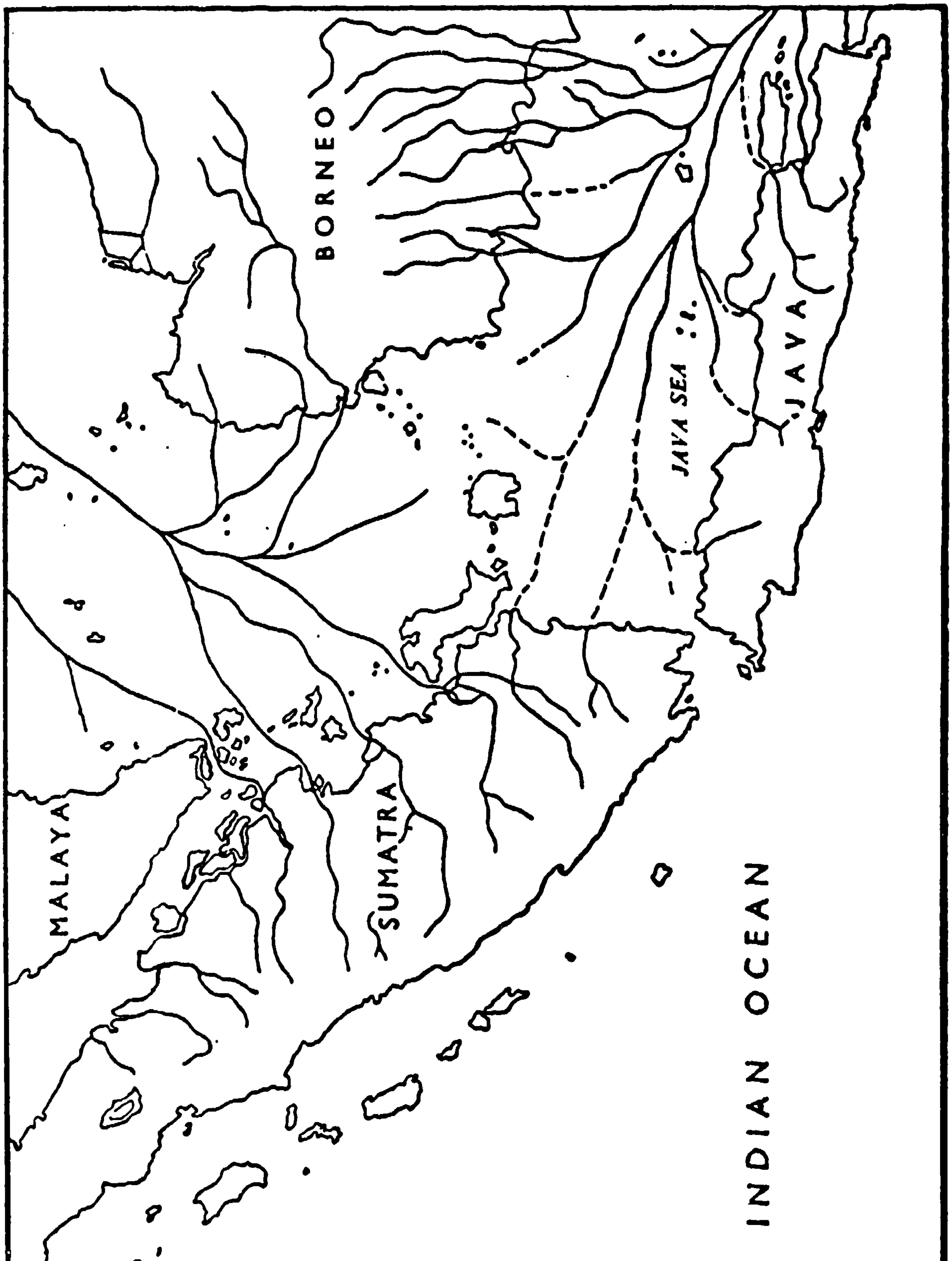


FIGURE 6.2 THE SUBMERGED DRAINAGE PATTERN IN THE SUNDA SHELF (MOLENGRAAFF IN UMBGROVE 1947)

land behind them, they now rise up from waters deeper than 72 meters (e.g. Pulau Panggang), and Molengraaff believed that the present islands indicated approximately where the shoreline of the Sunda Strait ended during the Pleistocene period. Umbgrove (1929a), however, regards that the morphology and alignment of the islands suggest that they have more likely developed on a ridge - formed elevation on the sea bottom (present in the Pleistocene) and that the deeper water channels formed between them are the result of the erosive action of currents (Figure 6:3).

At least part of Umbgrove's theory of island origin - that of the existence of a basement high below the reef - received some support from work on seismic sections of the area by Koesoemadinata and Pulunggono (1975).

There are also several other explanations of the origin of the islands and their reefs which are not mutually exclusive. In 1889 Sluiter proposed that a rock foundation was not essential for the formation of a coral reef and that a piece of shell or pumice could act as a focus for reef development through settlement of coral species such as Porites, Acropora and Montipora. It is perhaps noteworthy that the floor of Jakarta Bay is composed of loose sediments, which contain pumice at certain locations (Ongkosongo et al 1980).

Verwey (1931b) suggested that the islands were formed as a result of sedimentation processes on the leeward (south west) side of the reef while heavy coral debris was deposited on the windward (north east) reef edge. (Figure 6:4a) Keunen (1933b) later proposed a model in which sea level regression and predominant winds from the north east were held responsible for island formation (Figure 6:4b). More recently Scrutton (1978) put forward an explanation in which natural growth of corals and the subsidence of the burdened seafloor (figure 6:4c) were described as critical factors in island formation. All three of the latter explanations on the formation of islands have their weaknesses. The theories of Verwey (1931b) and Keunen (1933) cannot account fully for the existence of reef flats around islands such as Pari, while Scrutton's (1978) explanation does not explain the existence of raised corals and other indicators of higher former sea levels which are widespread around many of the islands e.g. Bidadari and Lancang.

Indications of palaeo-sea levels above the present level have been mentioned some half a century ago by Umbgrove (1928a, 1929, 1949) and Keunen (1933) and Table VI:2 summarises the heights recorded by these workers and more recently by Ongkosongo (1979). The interpretation of former higher sea levels was deduced from the existence of elevated coral reefs, platforms of abrasion, levels of the island, terraces of sand and 'in situ' position of Pelecypode fossils. The palaeo-levels can be grouped into categories of 4-5m; 2.5m; 1.5 - 2.0m; 0.3 - 1.0m which correspond with the curve of C14 datings in the Peninsular of Malaysia prepared by Tjia (1983).

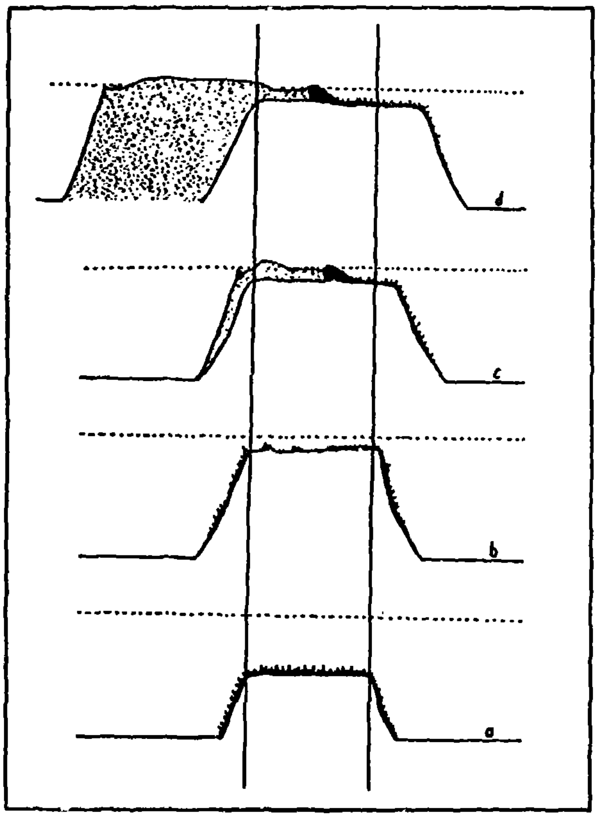
Influence of the monsoons on island geomorphology

(a) Wind direction

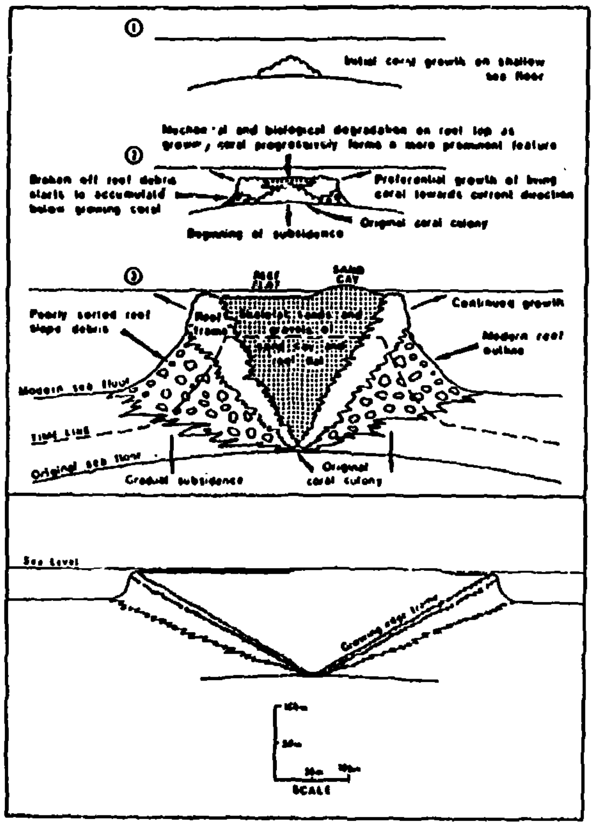
Umbgrove (1929b) proposed that the geological structure of the islands (i.e. sand banks, shingle ridges) gave a clear indication of influence of the monsoon winds on island geomorphology. He concluded that the wind was strongest from east to south, then from the north with other wind directions playing a very insignificant role i.e. the east monsoon exerts a stronger influence on the islands than the west monsoon.

FIGURE 6.3 **DEEP CHANNELS ALIGNED EAST-WEST BETWEEN THE KEPULAUAN SERIBU (after Umbgrove 1947)**

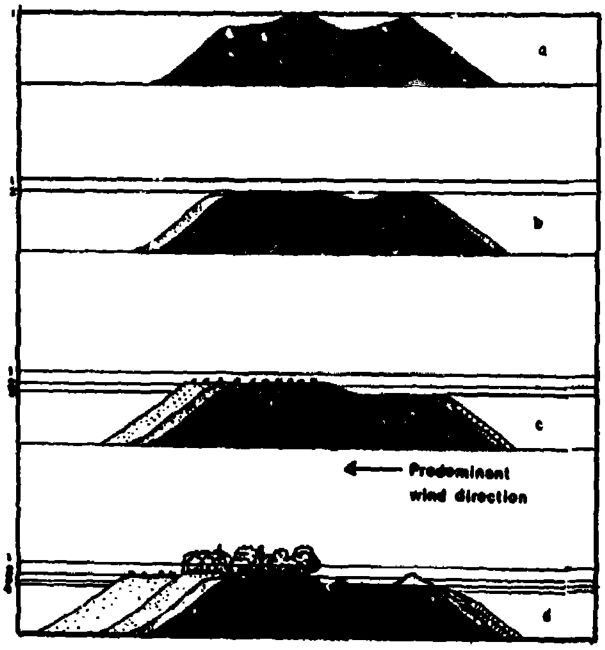
FIGURE 6.4 EXPLANATION OF THE FORMATION OF CORAL ISLANDS IN THE KEPULAUAN SERIBU



c.



b.



(a) Based on the natural growth of corals and the effects of erosion, sediment transport and accumulation. a-d represents the time sequence from submerged reef to emergent island.

- - - - - - = sea level (after Verwey 1931b)

(b) Based on the response of submerged reef to winds from one particular direction and subsequent build up of sediment together with lowering of sea level; a-d represents the time sequence from submerged reef to emergent island. 1-4 represents successive sea levels.

(after Keunen 1933)

(c) Based on the subsidence of the reef into the mud substrate and the subsequent growth of corals (sequence 1-3)

(after Scrutton 1978)

Table VI.2 Palaeo-sea level indicators above high tide in Kepulauan Seribu

Names of islands	Indicators	Elevation (m) above sea level	Author
Damar Besar	Coral	0.5	KUENEN (1933)
Damar Kecil	Coral Abrasion platform Sand cay	2; 4-5	KUENEN (1933)
	Coral	1-2	UMBGROVE (1928, 1929)
	Coral	0.5; 1-2	UMBGROVE (1949)
Nyamuk Kecil	Sand cay	1	KUENEN (1933)
Nyamuk Besar	Coral Sand cay	0.3-0.5	KUENEN (1933)
Air Besar	Coral Sand cay	1 0.75	KUENEN (1933)
Bidadari	Pelecypode Coral Sand cay	1(?) 1	KUENEN (1933)
Pari	Coral	0.5	ONGKOSONGO (1979)
Lancang	Coral Sand terrace Sand cay	0.5 0.5-0.8 2.5	ONGKOSONGO (1979)
Kapal	Coral	0.5	ONGKOSONGO (1979)

According to Umbgrove there is an important difference in wind influences between the southern most outer islands (e.g. Pari Island) and the islands of the Bay of Jakarta. In the case of the latter islands the surrounding land protects the islands from wind influences from the east and south east (i.e. east monsoon) and the islands are subject to greatest wind velocities from the north. Wind velocities in the Bay of Jakarta are much reduced when compared with those in the outer islands (Figure 6:5).

(b) Currents

The monsoon influence on the currents is clearly marked (Figure 6:6) and has been described in detail by Umbgrove (1929b). During January, February and March a west monsoon wind causes a current carrying cold and highly saline water, originating in the China Sea, to move eastwards. By April the east monsoon affects the eastern half of the Java Sea and the movement of water is already directed towards the west throughout the whole sea. By June, July and August the western current reaches maximum intensity.

Although the velocity of the east monsoon wind hardly subsides in September, the westerly current becomes noticeably weaker. In October and November a more complex pattern of currents is evident, with surface water flowing south-east, while undercurrents are directed eastwards. By December the west monsoon wind clearly manifests itself again as an easterly movement of water throughout the Java Sea. Overall the current pattern gives a westward current for approximately eight months and an eastward current for four months of the year.

During the west monsoon the velocity of the current through the Java Sea is approximately 28cm per sec towards the east and during the east monsoon 17cm per sec towards the west; so although the eastward current is predominant for only a short time during the year it has almost twice the strength of the westward current.

Umbgrove finally concludes that it is the erosive action of these sea currents, which only began to take effect from the end of the Pleistocene, that are responsible for the deep channels between the Kepulauan Seribu.

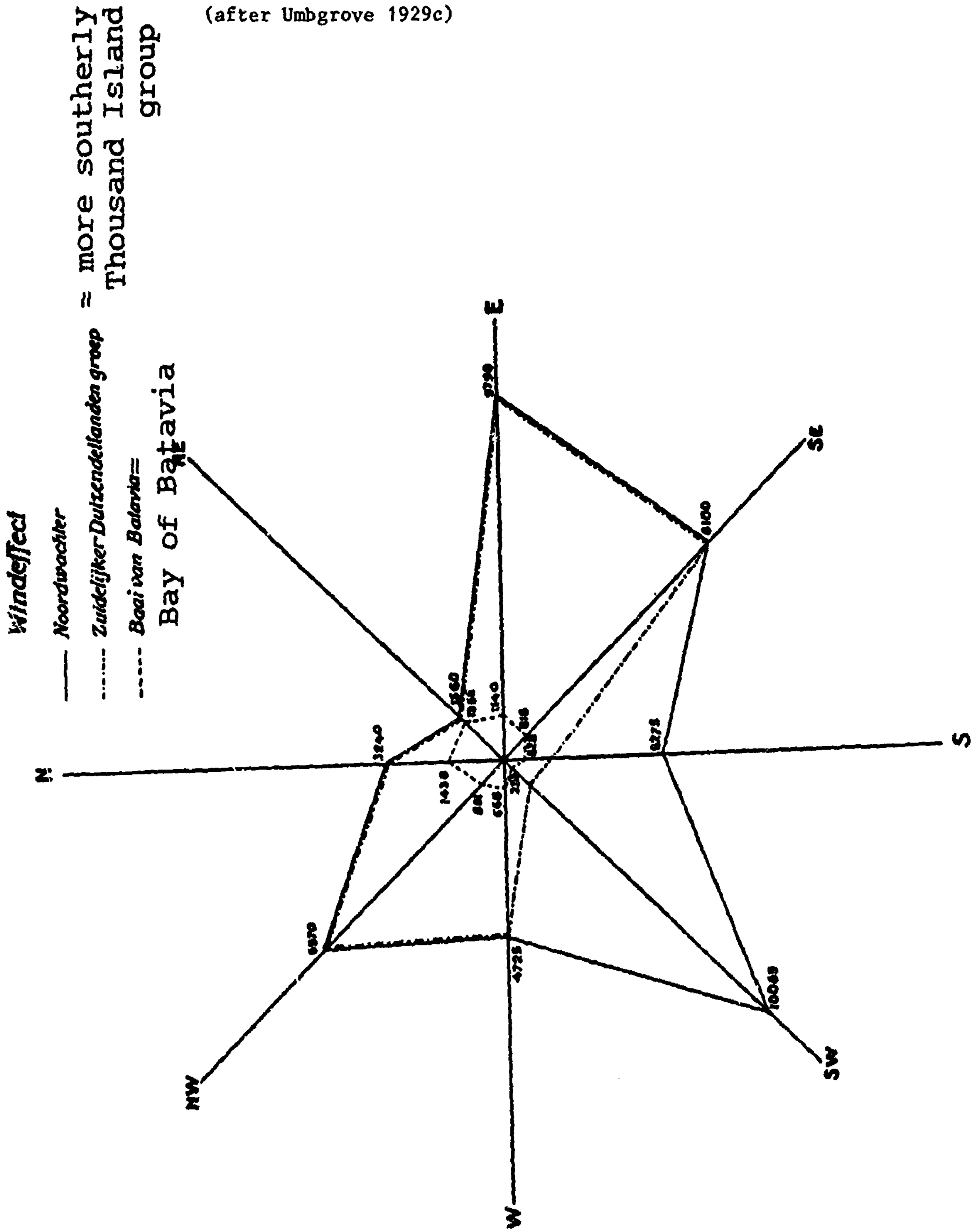
(c) Salinity

The salinity regime of the Java sea was first described by Umbgrove (1947). During the west monsoon cold, highly saline water penetrates the Java Sea from the China Sea. The pattern of distribution of this more saline water during January - June is shown in Figure 6:7, with the saline waters in the northern Java Sea described by Tjia (1966) as responsible for improved coral growth in the northern islands and also for the preferred growth of reefs in a NNW direction.

<u>Influence of the monsoon on the biology of the island reefs</u>

Umbgrove (1929a and b) was also the first scientist to study the reefs of the Java Sea in detail. In these early studies he recognised the important role of physical factors both in governing the morphology of the islands and the structure of the benthic communities or "facies" comprising the reef flats. Figure 6:8 illustrates the 'facies' he identified on coral reefs in the Bay of Jakarta.

FIGURE 6.5 WIND ROSE FOR ISLANDS IN THE BAY OF BATAVIA (BAY OF JAKARTA); THE MOST SOUTHERLY OF THE THOUSAND ISLANDS (e.g. Pulau Pari) AND THE MOST NORTHERLY ISLAND OF THE GROUP (e.g. Noordwatcher). FIGURES REPRESENT THE WIND EFFECT (PRODUCT OF NUMBER OF HOURS PER ANNUM THAT THE WIND BLOWS FROM THE 8 PRINCIPAL DIRECTIONS AND THE MEAN VELOCITY EXPRESSED AS M PER SEC) (after Umbgrove 1929c)



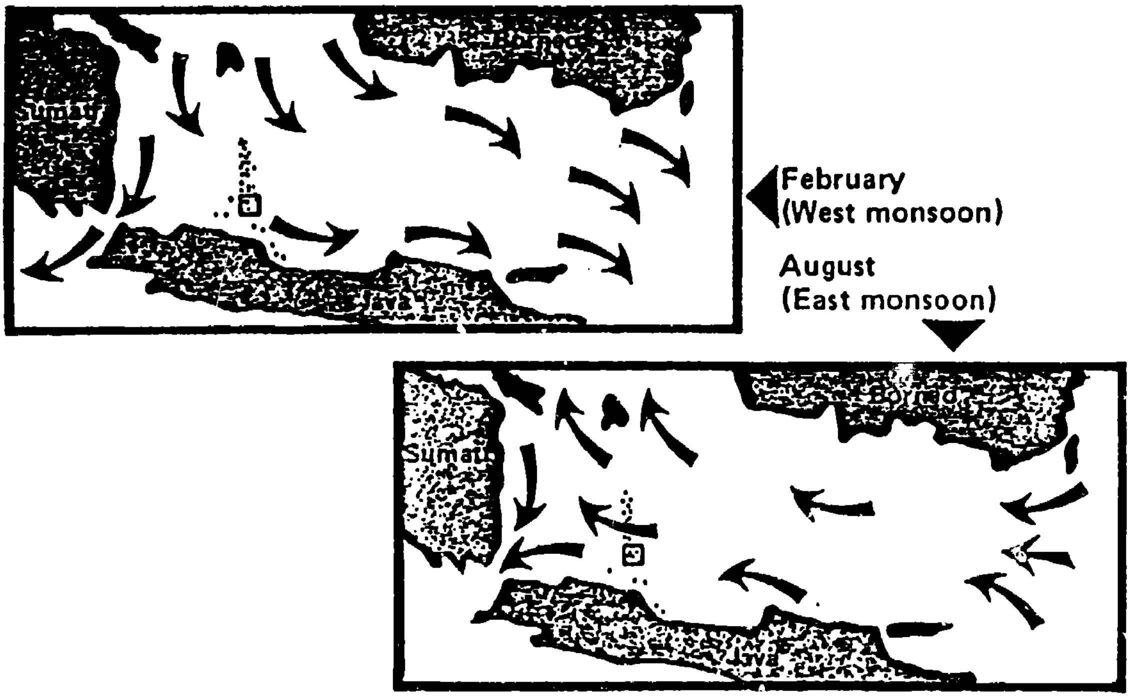


FIGURE [illegible].6 THE INFLUENCE OF THE REVERSING MONSOON ON THE DIRECTION OF CURRENT SYSTEMS IN THE JAVA SEA
(after Umbgrove 1947 and Wyrtki 1961)

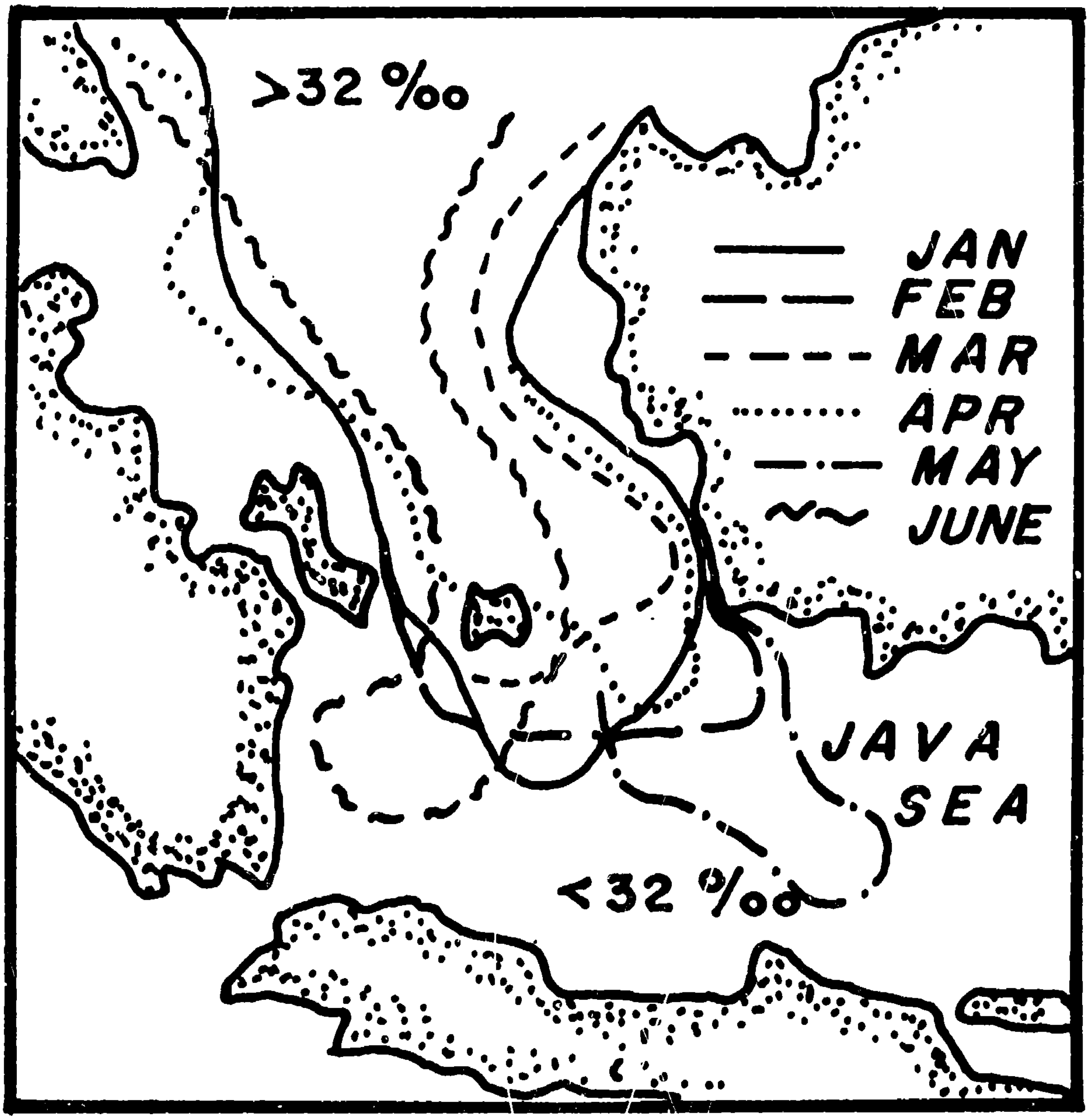
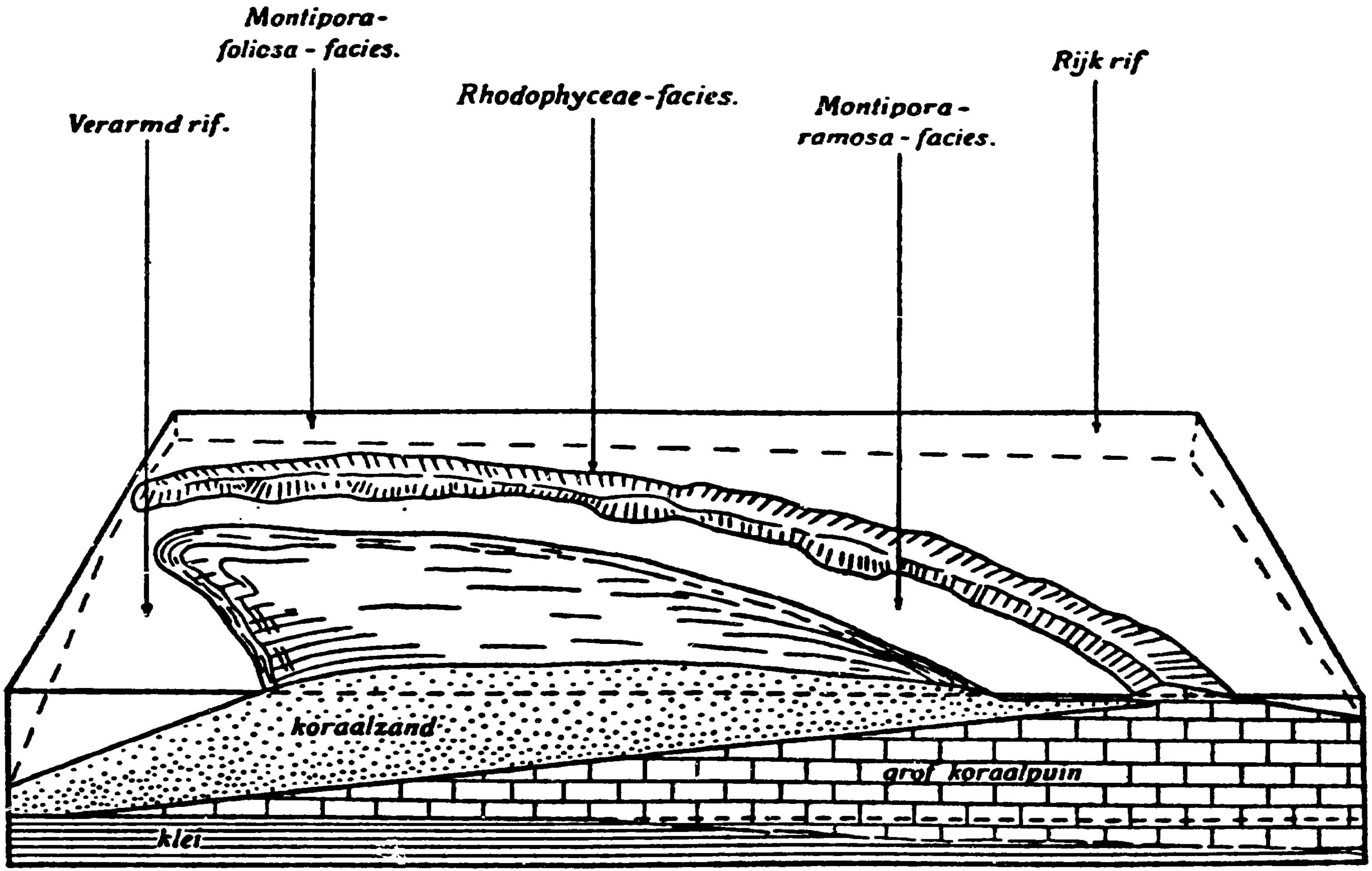


FIGURE 6.7 THE ISOHALINES IN THE JAVA SEA SHOWING THE INFLUENCE OF SALINE WATER FROM THE SOUTH CHINA SEA ON THE SALINITY REGIME IN THE VICINITY OF THE KEPULAUAN SERIBU (after Tjia 1966)

FIGURE 6.8 THE REEF FACIES DESCRIBED BY UMBGROVE (1928a) FOR ISLANDS IN THE BAY OF JAKARTA, SHOWN IN A CROSS-SECTION THROUGH THE ISLAND



Klei = Silt
Koraalzand = Coral sand
grof Koraalpuin = coral limestone

verarmd rif = leeward reef
rijk rif = seaward reef

In 1983 Brown and Holley worked on coral assemblages of reef flats around Pulau Pari in the southern Kepulauan Seribu. Their paper described the similarities in reef structure observed by Umbgrove in the Bay of Jakarta with those seen at Pari Island. Features noticed at Pari Island such as the Montipora ramosa dominated moat, the northerly located shingle ramparts and the abundance of Montipora foliosa on the northwest side of the island complex are all characteristics of reefs described by Umbgrove in the Bay of Jakarta.

There are however important differences between reefs in the Bay of Jakarta and the Pari Island complex. Firstly, the shingle ramparts of Pari Island are restricted to the north east and eastern sectors of the complex and do not extend along the entire northern border as described for reefs in the Bay of Jakarta. Secondly, Umbgrove describes the reefs of the south west sector of the islands in the Bay of Jakarta as showing an impoverished reef facies because of a strong sedimentation effect in the area. Within the Pulau Pari complex the reefs of the southern islands, in fact, show a much more diverse coral assemblage than those encountered to the north, east or west.

Thus the degree of physical exposure is critical to the diversity and condition of reefs in the Kepulauan Seribu. In the Pulau Pari complex, it is likely that the islands are subject to a much more 'all around' influence, than those in the Bay of Jakarta and as a result diversity is favoured on the relatively more protected reefs of the southern sector.

In assessing the effects of man-made damage on coral reefs, modifying physical factors such as the reversing monsoon and its variable effects on the chain of islands in the Kepulauan Seribu, must be taken into account, before ascribing reduced coral diversity to anthropogenic sources.

Man-made influences in the Kepulauan Seribu

Although man may stimulate and promote growth of corals by providing a foundation for coral settlement (e.g. establishment of an artificial reef at Kotok Kecil in Kepulauan Seribu by Sukarno and co-workers (unpubl.) most man-made influences on reefs in the Java Sea have been deleterious. Reefs in the Bay of Jakarta are generally in a relatively poor condition (Harger and Sukarno unpubl.) as shown in Table VI.3 which documents not only the status of the reef but also the condition of the island.

Man-made influences on reefs in the Kepulauan Seribu have already been summarised in Chapter I (Table I.1). Figures for exploitation of coral from the reefs are available from the earlier part of the century when Hardenberg (1993) reported an estimated removal of between 12,000 - 25,000^3 of coral reef annually. Verwey (1931b, 1934) estimated an annual removal of 8,500 -20,000m^3 of coral reef in the Kepulauan Seribu. In recent years it has been proposed that the scale of exploitation has escalated (Figure 6.9) with values in 1982 double that recorded in 1979. (Sya'rani and Willoughby 1983).

The most significant removal of coral reef in the Bay of Jakarta has been around the islands of Air Kecil and Ubi Kecil. As a result of subsequent erosion both islands have now disappeared. At Ubi Besar the island is rapidly being eroded as the reef is dredged around it. Extensive dredging activities have been allowed to proceed (despite regulations banning exploitation of sand, gravel and boulders by the local governor) in order to provide construction material for the new international airport at Cengkareng.

Table VI.3 Status of coral reefs and islands in the Bay of Jakarta. The symbol + indicates which characteristics apply to each habitat.

Name of Island/Reef	Status of corals and the island							
	Almost all/ Totally destroyed		Majority destroyed		Partly destroyed		Good condition	
	Coral Reef	Island	Coral Reef	Island	Coral Reef	Island	Coral Reef	Island
Nyamuk Besar	+			+				
Nyamuk Kecil	+			+				
Damar Kecil			+			+		
Damar Besar					+			+
Bidadari			+			+		
Cipir			+			+		
Kapal			+			+		
Kelor	+			+				
Air Besar			+			+		
Air Kecil	+	+						
Ubi Besar	+	+						
Utung Jawa					+			+
Rambut							+	+
Dapur			+	+				
Bokor							+	+

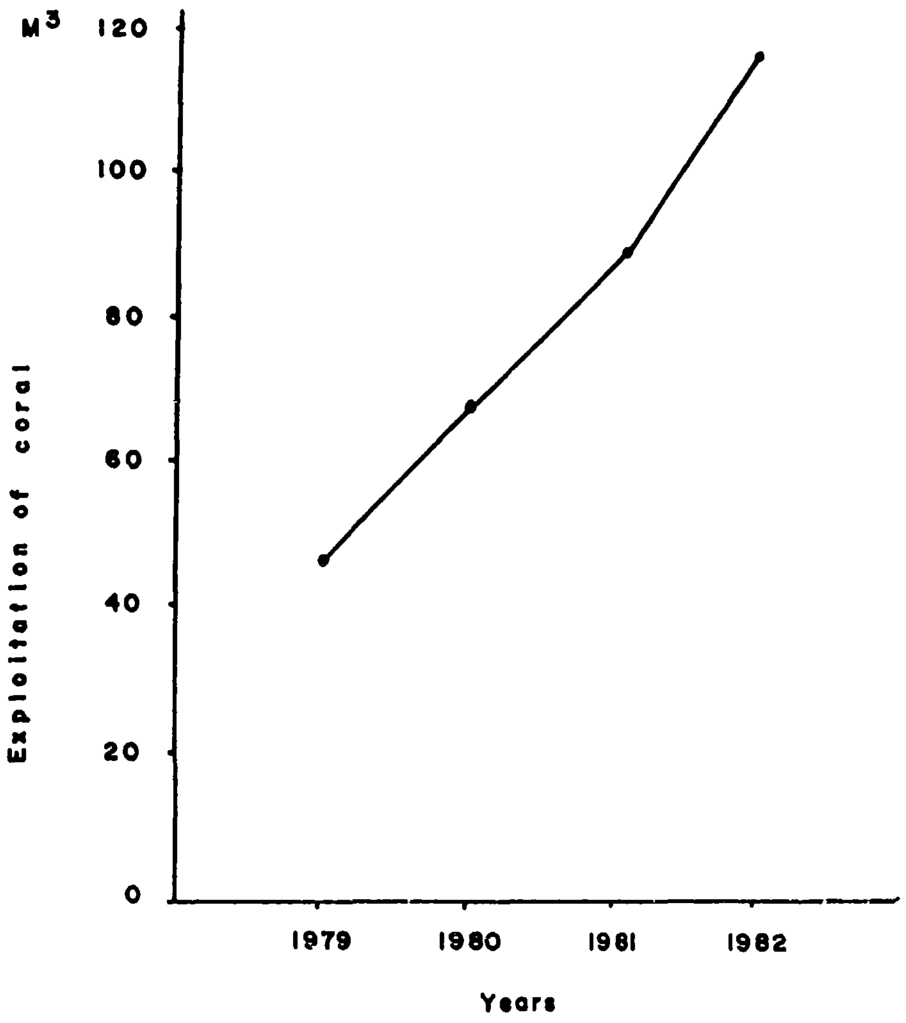


FIGURE 6.9 EXPLOITATION OF CORAL PER PERSON PER ANNUM IN THE SERIBU ISLANDS FROM 1979-1982

Reefs in Jakarta Bay are also subject to pollution from oil (as a result of tanker discharges and spillages), heavy metals (from industrial and sewage sources), increased nutrient levels (raw sewage), sedimentation and freshwater run off.

In 1982 Salm, Halim and Soehartono produced a management plan for the proposed Kepulauan Seribu marine national park. A zoned system was proposed in which sanctuary zones, intensive use and tourist development zones, pursuit zones, wilderness zones and buffer zones were created (Figure 6:10 and Table VI.4). (Salm 1984). The scheme has yet to be implemented, even though the Kepulauan Seribu was declared a national reserve in July 1982.

References

Brown, B.E., M.C. Holley, L. Sya'rani and M. Le Tissier (1983). Coral assemblages of reef flats around Pulau Pari, Thousand Islands, Indonesia. Atoll Res. Bull. 281, 1-14.

Brown, B.E., L. Sya'rani and M. Le Tissier (1985). Skeletal form and growth in Acropora aspera (Dana) from the Pulau Seribu, Indonesia. J. Exp. Mar. Biol. Ecol. 86, 139-150.

Keunen, P.H. (1933). Geology of coral reefs. Snellius. Exp. East Part. Neth. East Indies 5 (2).

Koesoemadinata, R.P. and A. Pulunggono (1975). Geology of the Southern Sunda Shelf in reference to tectonic framework of tertiary sedimentary basins of Western Indonesia. Gol. Indon. 2, 1-11.

Molengraaff, G.A.F. (1922). Geologie. In: 'De zeen van Nederlandsch Oost-Indie', 272-357.

Morner, N.A. (1982). Sea level changes. In: 'The encyclopedia of beaches and coastal environments' Ed. M.L. Schwartz, pp 722-733. Hutchinson Ross Publ. Comp., Stroundsburg.

Ongkosongo, O.S.R. (1979). Masa depan Karang Pulau-pulau Seribu, dengan penekanan yang terletak di Teluk Jakarta. PIT VIII IAGI, Jakarta 22p.

Ongkosongo, O.S.R. (1984). Evolution et effects des amengements dans l'environment cotier de la Baie de Jakarta, Indonesie. Doct. Thesis Univ. Bordeaux 411p.

Ongkosongo, O.S.R., Subardi, Susmiati, Lukman Effendi, A. Suwardi dan P. Hamidjojo (1980). Sedimen Dasar Teluk Jakarta Lembaga Oseanologi Nasional (LON) LIPI, Jarkarta p. 395-407.

Salm, R.V., M. Halim and T. Soehartono (1982). Proposed Pulau Seribu Marine National Park Management Plan. Field Report of DP/FAO National Parks Development Project. Bogor January 1982, 48p.

Salm, R.V. (1984). A case study site design: The Pulau Seribu Marine National Park. In 'Marine and Coastal Protected Areas: a guide for planners and managers' ed. R.V. Salm and J.R. Clark, 255-264.

Scrutton, M.E. (1976). Aspects of carbonate sedimentation in Indonesia. Robertson Research - LEMIGAS. Jakarta 19p.

Scruttton, M.E. (1978). Modern reefs in the West Java Sea. Proc. of the Carbonate Seminar, Indonesian Petrol Assoc. September 12-19, 1976, Jakarta, 14-36.

Sluiter (1889). Einiges uber die Enstelung der Korallenriffen in der Javasee und Brantweinsbai, und uber neue Korallenbildung Kraktau, Natuurk. Tijdschr. Nederl. Indie, 49, 360-380.

Sukarno (1972). Corals and coral reef study in Indonesia. Proc. Symp. on Coral and Coral Reefs. J. Mar. Biol. Ass. (India) 1, 175-180.

Sya'rani, L. (1983). Ecology of shallow water coral communities in the Java Sea, Indonesia. PhD thesis, Univ. Newcastle upon Tyne, 202p.

Sya'rani, L. and N.G. Willoughby (1983). Marine resources management in the Java Sea, some case histories. Seminar in Traditional mangagement of Coastal Systems. UNESCO Jakarta, 13p.

Tjia, H.D. (1966). Java Sea. In: 'The Encyclopedia of Oceanography' ed. R.W. Fairbridge. 424-429. Reinhold Publ. Comp. New York.

Tjia, H.D. (1983). Aspek geologi Kuarter Asia Tenggara. Bull. Jur. Geol. 9, 1-22.

Umbgrove, J.H.F. (1928a). De koraalriffen in de baai van Batavia. Dienst. v.d. Mijnb. in Ned. Indie, Wetensch Meded. 7, 68p.

Umbgrove, J.H.F. (1928b). De invloed van de wind op de vorming de baai van Batavia. Trop. Nat. 17: 123-130.

Umbgrove, J.H.F. (1929a). The coral reefs in the bay of Batavia. I. Geology. Fourth Pac. Sci. Congr., Excursion A2, Java, Bandoeng, 1-15.

Umbgrove, J.H.F. (1929b). The influence of the monsoons on the geomorphology of coral islands. Proc. Fourth Pac. Sci. Congr., 2, 49-54.

Umbgrove, J.H.F. (1929c). De koraalriffen der Duizend-Eilanden (Java-Zee). Dienst. v.d. Mijnb. in Ned. Indie, Westensch. Meded. 12, 74p.

Umbgrove, J.H.F. (1939). Madreporaria from the bay of Batavia. Zoologische Meded. 22 (1-2), 1-64.

Umbgrove, J.H.F. (1947). Coral reef in the East Indies. Bull. Geol. Soc. Amer. 58, 729-778.

Umbgrove, J.H.F. (1949). Structural history of the East Indies. Cambridge Univ. Press, 63p.

Verstappen, H. Th. (1952). A recent investigation on the geomorphology and the flora of some coral islands in the Bay of Djakarta. I. Geomorphology. Kement. Pertah. Djaw. Top. A.D., Inst. Geogr., Publ. 4 Djakarta: 17p.

Versappen, H. Th. (1953a). Djakarta Bay, a geomorphological study on shore line development. Doct. Dissertation, Rijnksuniversiteit, Utrecht, Drukkerrij Trio, 'S-Gravenhage, 101p.

Verstappen, H. Th. (1953b). Oude en neuve onderzoekingen overde koraaleilanden in de baai van Djakarta. Tijds. Kon. Ned. Aardr. Gen. 70 (4): 470-478.

Verstappen, H. Th. (1954). The influence of climatic changes on the formation of coral islands. Amer. Journ. Sci. 252, 428-435.

Verstappen, H. Th. (1968). Coral reefs, wind and current growth control. In: "Encyclopedia of Earth Science", ed. R.W. Firbridge, 197-202. Reinhold Publ. Corp., New York.

Verstappen, H. Th. (1977). Applied Geomorphology. Lecture notes, ITC, Enschede, 40p.

Verstappen, H. Th. (1983). Applied geomorphology. Elsevier, Amsterdam, 437p.

Verwey, J. (1931a). Coral reefs studies II. The depth of coral reefs in relation to their oxygen consumption and the penetration of light in the water. Treubia 13 (2), 169-198.

Verwey, J. (1931b). Coral reef studies III. Geomorphological notes on the coral reefs of Batavia Bay. Treubia 13 (2), 199-215.

Verwey, J. (1934). Koraalriffen en zoulicht. Trop. Nat. 23, 137-145.

Wyrtki, K. (1961). Physical oceanography of the Southeast Asian waters. Naga Rep. 2, p 195.

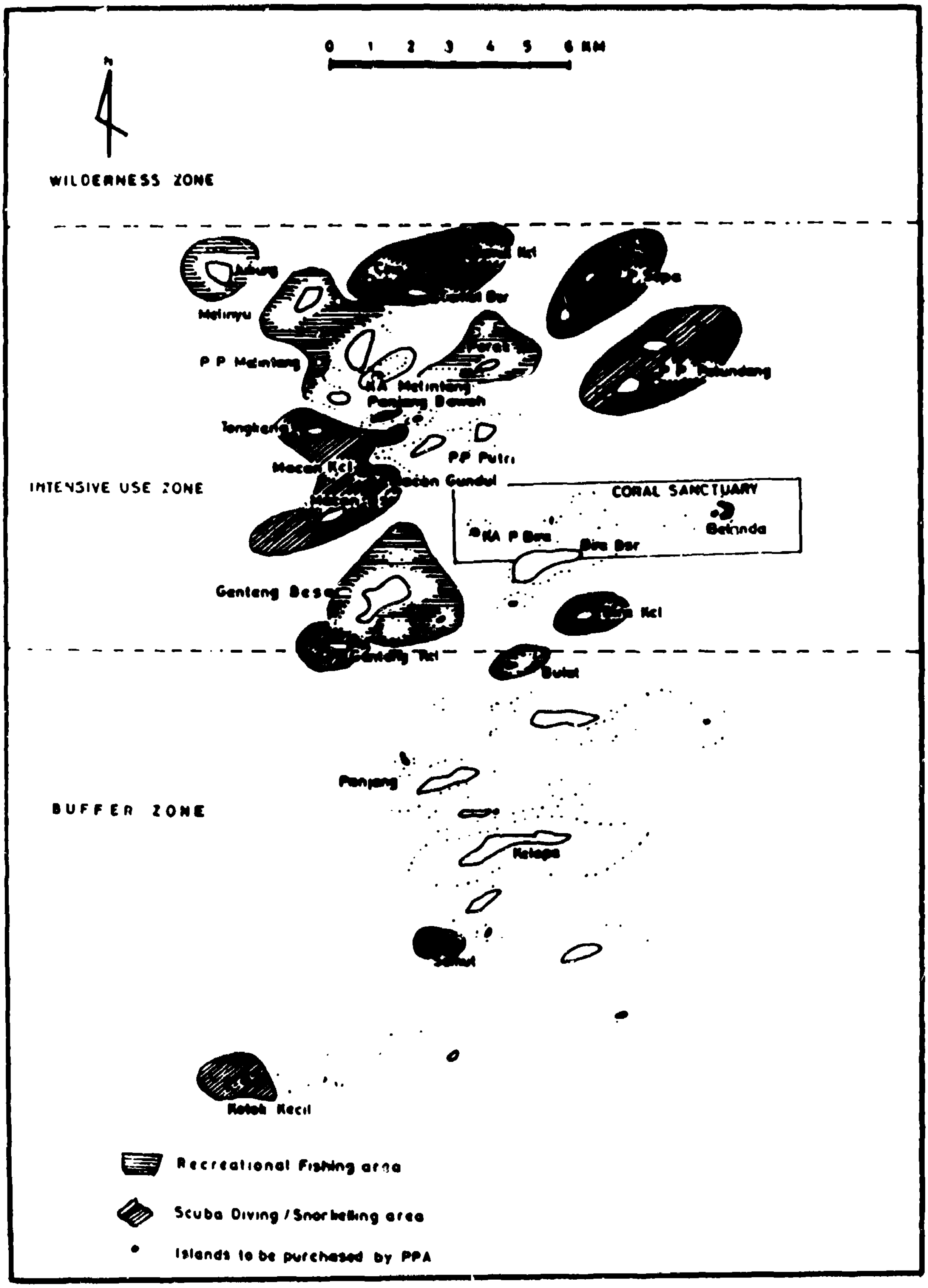


FIGURE 6.10 RECREATION AREAS IN THE INTENSIVE USE AND BUFFER ZONES OF THE PULAU SERIBU MARINE NATIONAL PARK, INDONESIA (after Salm et al 1982)

Table VI.4 Zone Objectives, Compatible Uses, and Restrictions at Kepuluan Seribu Marine National Park, Indonesia (after Salm et al. 1982, Salm 1984) (PPA refers to the Indonesian Directorate of Nature Conservation)

Zone and Objectives	Compatible Uses	Restrictions
Hawksbill turtle sanctuary: protection of the nesting, resting, and feeding habitats of the hawksbill turtle (Eretmochelys imbricata) to enable recovery of the breeding population	Routine patrol, enforcement action and periodic inspection by PPA[a] marine park staff Nonmanipulative, nonextractive research subject to written PPA consent and in company of PPA marine park staff	Access by all but PPA marine park staff and accompanying researchers Damage, alteration, collection, or extraction of all marine or terrestrial products from the reefs or islands Disturbance of nesting turtles Unearthing of nests and manipulation or removal of eggs
Coral sanctuary (core zone): protection of representative samples of reef organ- for replenishment of damaged or depleted areas	Routine, enforcement action, and periodic inspection by PPA personnel Nonmanipulative, nonextractive scientific research subject to written PPA consent and in company of marine park staff	Access by all but PPA marine park staff and accompanying scientists Damage, alteration, collection, or extraction of all marine products whether living or dead
Intensive use and tourism development zones: development of tourist facilities and recreational activities, and protection of reefs and their associated habits, communities, and species from the adverse effects of these developments	PPA-approved construction of tourist or private lodgings and boat docking facilities Navigation and operation of boats except as restricted by general marine park or specific recreational area regulations	Operation of aircraft less than 500 m altitude except on the approaches to the airfield on P.Panjang Operation of motorized vessels at more than 15 km/h except in lane designated for boat passage, or in designated waterskiing areas.
	Recreational activities except as restricted by the specific limitations of each recreation area Coconut plantations and other agricultural activities Any nonextractive activities consistent with the objectives of the zone which are not in conflict with general marine park regulations	Building of residences, catering facilities, or other shelters or structures other than piers within 15 m of the mean high waterline Felling, pruning, uprooting, transplanting, or otherwise disturbing any of the following plants: Scaevola, Hibiscus tiliaceous, Calophyllum,

Zone and Objectives	Compatible Uses	Restriction
		Barringtonia, *Terminalia*, *Pemphis*, *Suriana*, *Tournefortia*, *Pandanus*, *Spinifex*, *Ipomoea*, *Casuarina*, *Rhizophora*, *Avicennia*, *Sonneratia*, *Bruguiera*, *Ceriops* Building of piers, groins, breakwater seawalls, or any other structure in, across, or seawards of the intertidal zone without previous written consent of PPA Digging of channels or dredging or removal of snad, rock, or coral from the reefs, reef flat, or beaches All other activities prohibited by the general marine park regulations
Pursuit zones; pursuit of different recreational activities with maximum safety and minimum conflict with other activities, where the effects of these activities on the environment can be contained and easily monitored	Snorkelling and SCUBA diving: (1) snorkelling and SCUBA diving at buoyed sites to pursue such nondamaging underwater activities as fish watching, reef appreciation, photography, education, and guided tours; (2) operation of glass-bottomed or glass-sided boats or boats with glass-bottomed viewing buckets except closer than 300 m to occupied mooring buoys	Standing, holding, breaking or collecting coral or other attached or free living reef life, whether living or dead Feeding of fish at sites other than those designated for this purpose
	Recreational fishing: trolling with lure and over the forereef or seawards thereof for recreational purposes only	Fishing for commercial purposes Catching more than two fish per person per day Spearfishing Stationary fishing and anchoring Drift fishing Bait fishing Trap and net fishing
	Picnicking and beach-based activities: all nonextractive beach-based activities except locations where the activities (eg. football, volleyball) may damage beach vegetation or cause inconvenience to others.	Littering All activities restricted by the general marine park regulations

Zone and Objectives	Compatible Uses	Restriction
	Boating: (1) access to all parts of the marine park, other than the sanctuary zones, by non-motorized vessels; (2) motorboating except as restricted by general speed limits and specific zone or recreation area limitations; (3) waterskiing in all areas without speed limits areas; (4) access to sanctuary or extraordinary patrol and inspection	Speeds in excess of defined limits by all motorized craft other than PPA vessels in the course of enforcement action Entry to sanctuary zones
Wilderness zone (low intensity use): provision for appreciation of marine park in natural setting, protection of reefs and associated habitats and stocks for replenishment of surrounding fishing grounds	Development of PPA-approved rustic accommodations and camping grounds Overnight stay in designated areas Nonextractive recreational activities including buoyed locations, beachcombing, swimming sunbathing, picnicking, windsurfing, sailing rowing, and canoeing Exploration and cruising by sailing boats or other nonmotorized craft Operation of motorized vessles (maximum speed 15 km/h) for access to camping sites only PPA-approved nonmanipulative scientific research	Littering or discarding foodstuffs other material anywhere on the islands or in the sea except in the receptacles provided. Removal or harvest of any marine or island product, living or dead from islands, beaches, reefs, or their surrounds, except for coconuts by plantation owners Feeding or disturbance of fishes or invertebrates Cutting vegetation or damage to plant or animal life on land or in the sea Overnight stay anywhere except the areas designated for this purpose Construction of any form of shelter or facility, temporary or permanent, without prior consent from PPA Digging or clearing of boat channels Anchoring of craft anywhere except on sandy areas away from reefs when mooring buoys are fully occupied

Zone and Objectives	Compatible Uses	Restrictions
Buffer zone: continuation of all traditional or established uses and activities other than those which are damaging to the environment, incompatible with marine park objectives or restricted by regulations	Hook and line, net trap, and trawl commercial and subsistence fisheries except as bound by specific regulations Trapping or catching of reef fishes and invertebrates for the aquarium trade All nonextractive recreational activities	Fishing with poisons, other chemicals or spearguns Anchoring, walking, or poling over reefs Collection and mining of coral and *Tridacna*, living or dead, or of rock and hydrocarbons Harvest of turtles or turtle eggs Possession of spearguns, fish poisons, turtles and turtle products, corals and *Tridacna* Recreational fishing, except in designated areas Commercial fishing, except by licenced residents fo the two administrative districts Kelurahan Panggang and Kelurahan Kelapa in their respective districts

CHAPTER SEVEN

UMBGROVE'S ISLANDS REVISITED

D.R. Stoddart
Department of Geography
University of Cambridge
Downing Street, Cambridge
United Kingdom

(with text summary by B.E. Brown)

Islands in Jakarta Bay were first mapped in 1874. It is possible to construct maps which show the changes in island morphology over time using the earlier work of Umbgrove (1928); Verwey(1931); Hardenberg (1939) and particularly Verstappen (1953).

During the course of the workshop thirteen islands, which had previously been described in the literature, were revisited and mapped. These included Air Besar, Air Kecil, Bidadari, Cipir, Damar Besar, Damar Kecil, Kelor, Dapur, Nyamuk Besar, Nyamuk Kecil, Ubi Besar, Ubi Kecil and Undrus. Three islands, Bokor, Rambut and Utung Jarva were mapped for the first time during the workshop. Figure 7.1 shows the position of the islands in the Bay of Jakarta and Figures 7.2 a-p, the changing morphology of the islands over time.

Alterations in the shape of islands, their vegetation patterns and beach features are clear. In particular the islands of Air Kecil, Ubi Kecil and Ubi Besar have suffered severe erosion as a result of coral reef dredging which has taken place around them. The islands of Air Kecil and Ubi Kecil disappeared in 1983, while the island of Ubi Besar will soon follow the same fate.

References

Hardenberg, J.D.F. (1939) De Koraaleilanden in de baai van Batavia. IIe Versl. Ned. Verg. v. Natuurbesch, 232-242.

Umbgrove, J.H.F. (1928) De Koraalriffen in de baai van Batavia. Dienst, v. d. mijnb. in Ned. Indie, Wetensch. Meded. 7, 68p.

Verstappen, H. Th. (1953) Oude en neuve onderzoekingen overde Koraaleilanden in de baai van Djakarta. Tijds. Kon. Ned. Aardr. Gen. 70, 470-478.

Verwey, J. (1931) Coral reef studies III. Geomorphological notes on the coral reefs of Batavia Bay. Treubia 13, 199-215.

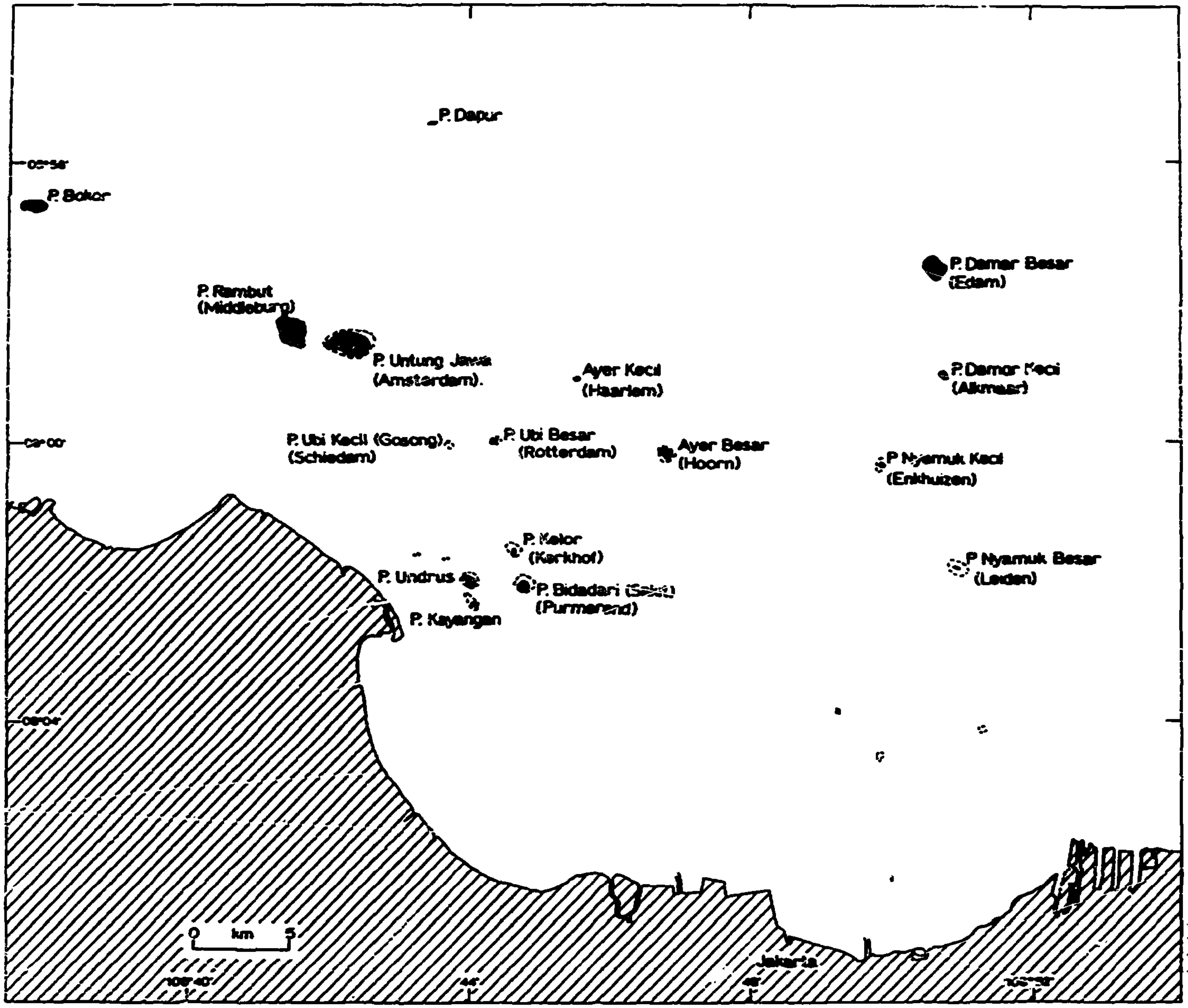
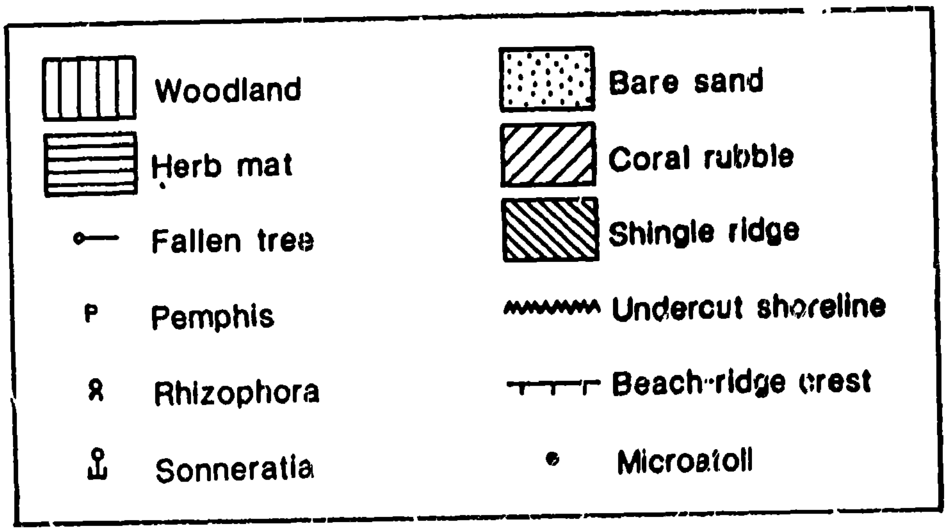


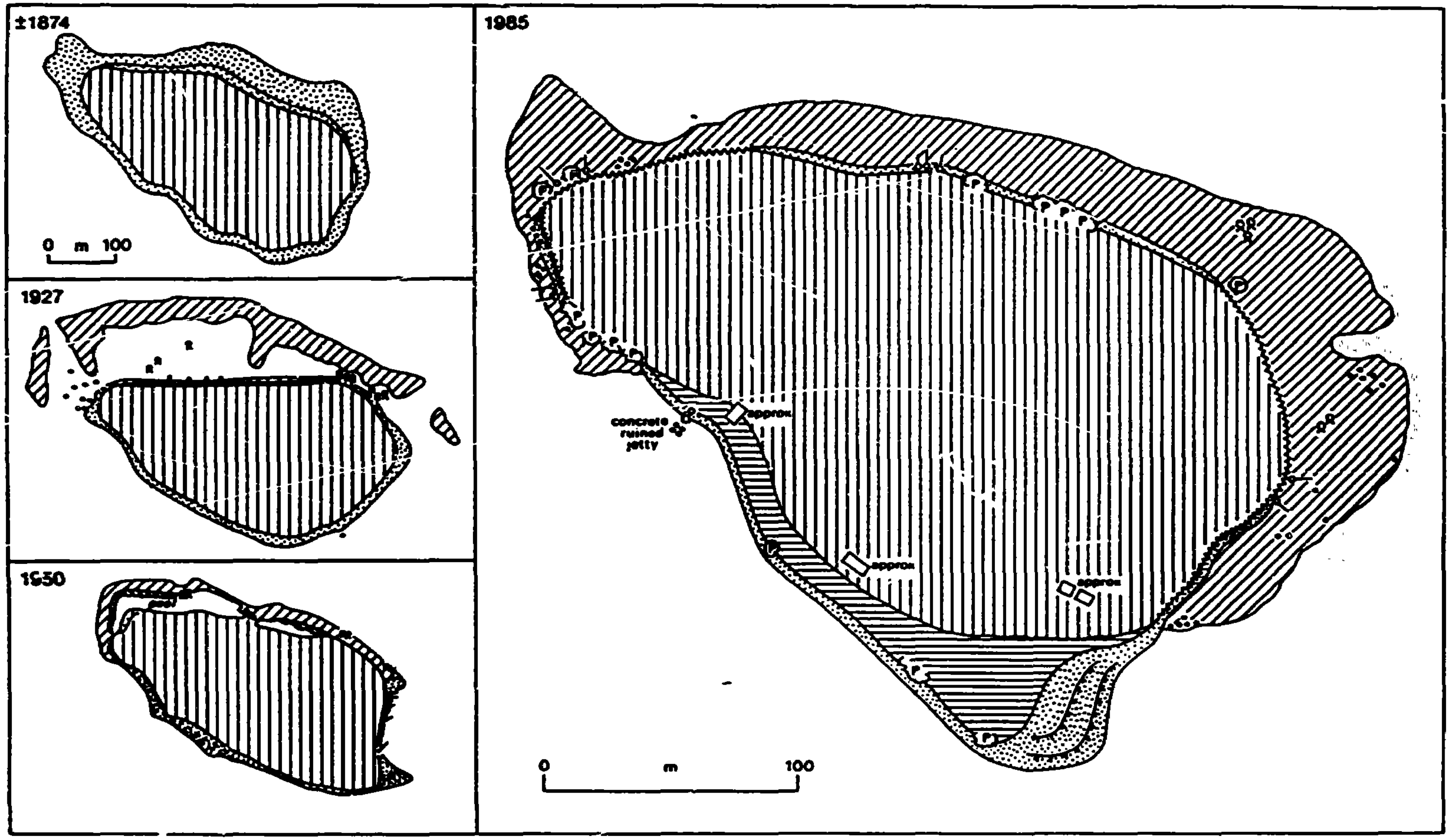
FIGURE 7.1 LOCATION OF ISLANDS IN THE BAY OF JAKARTA

FIGURE 7.2 MAPS OF ISLANDS IN THE BAY OF JAKARTA SHOWING CHANGES IN THEIR MORPHOLOGY OVER TIME

(a) Air Besar
(b) Air Kecil
(c) Bidadari (Sakit)
(d) Bokor
(e) Cipir
(f) Damar Besar
(g) Damar Kecil
(h) Kelor
(i) Dapur
(j) Nyamuk Besar
(k) Nyamuk Kecil
(l) Ubi Besar
(m) Undrus
(n) Ubi Kecil
(o) Rambut
(p) Untung Jawa

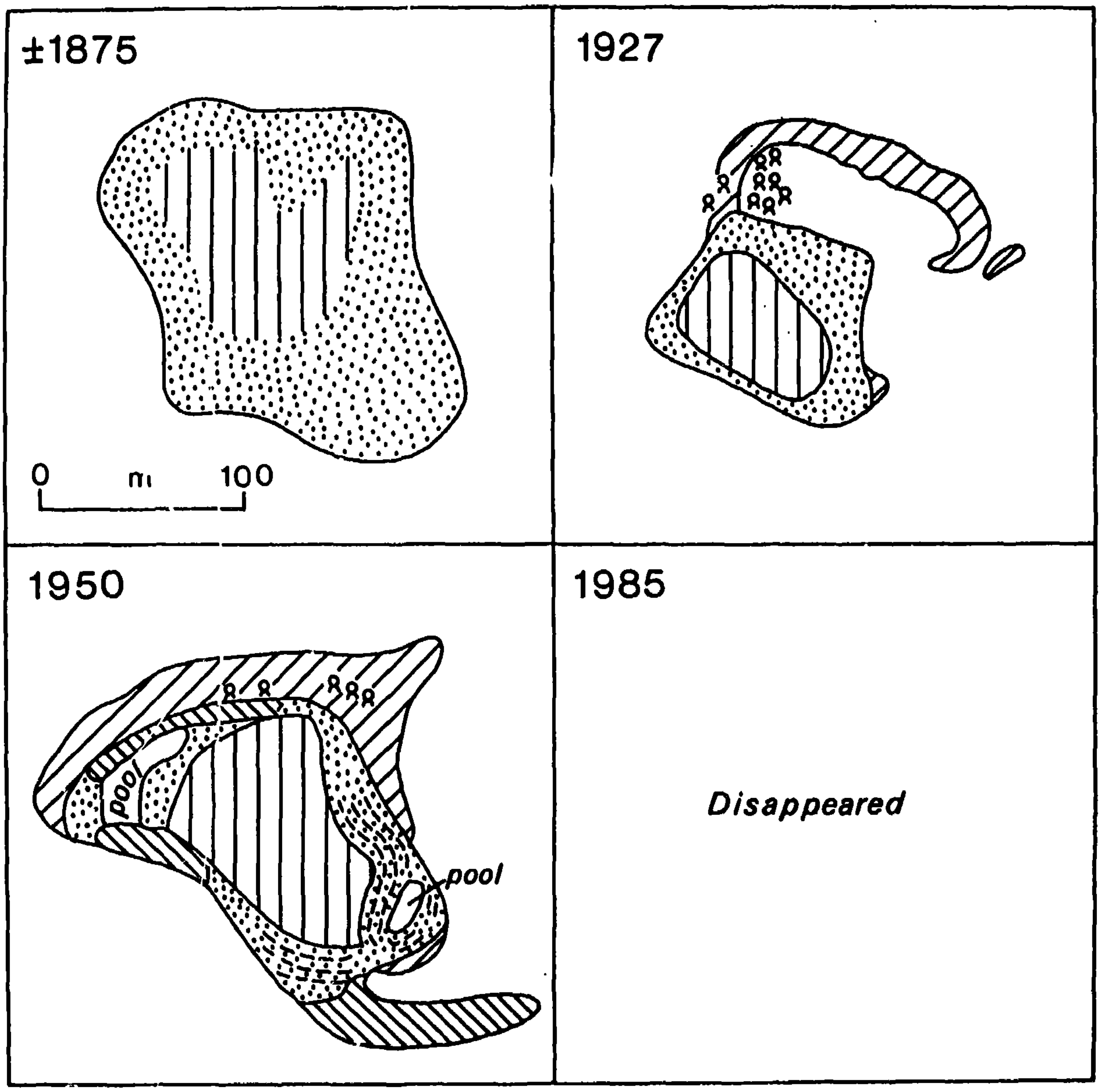


a.


±1874
0 m 100
1927
1930
1985
concrete
ruined
jetty
approx
approx
approx
0 m 100

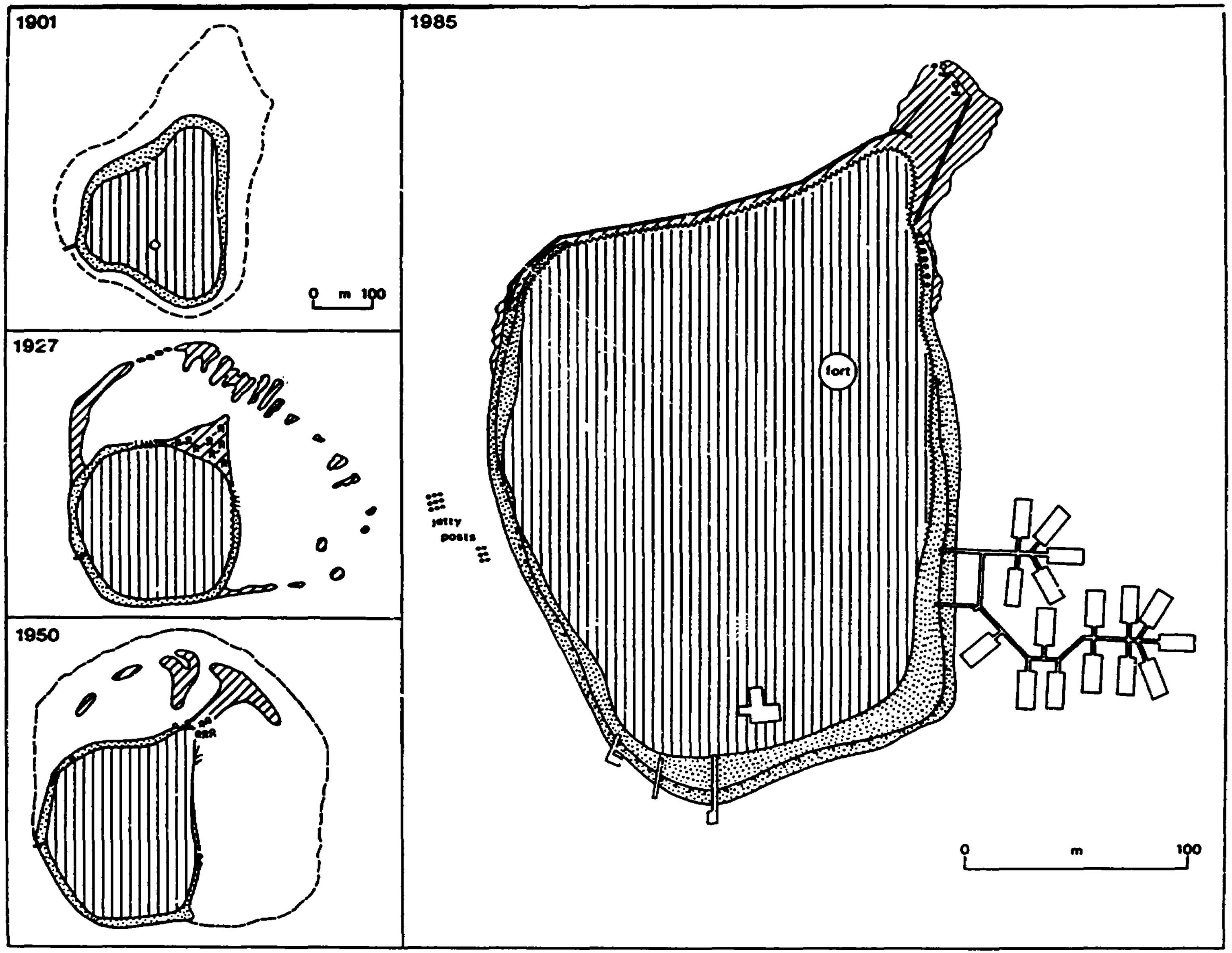
Air Besar

b.



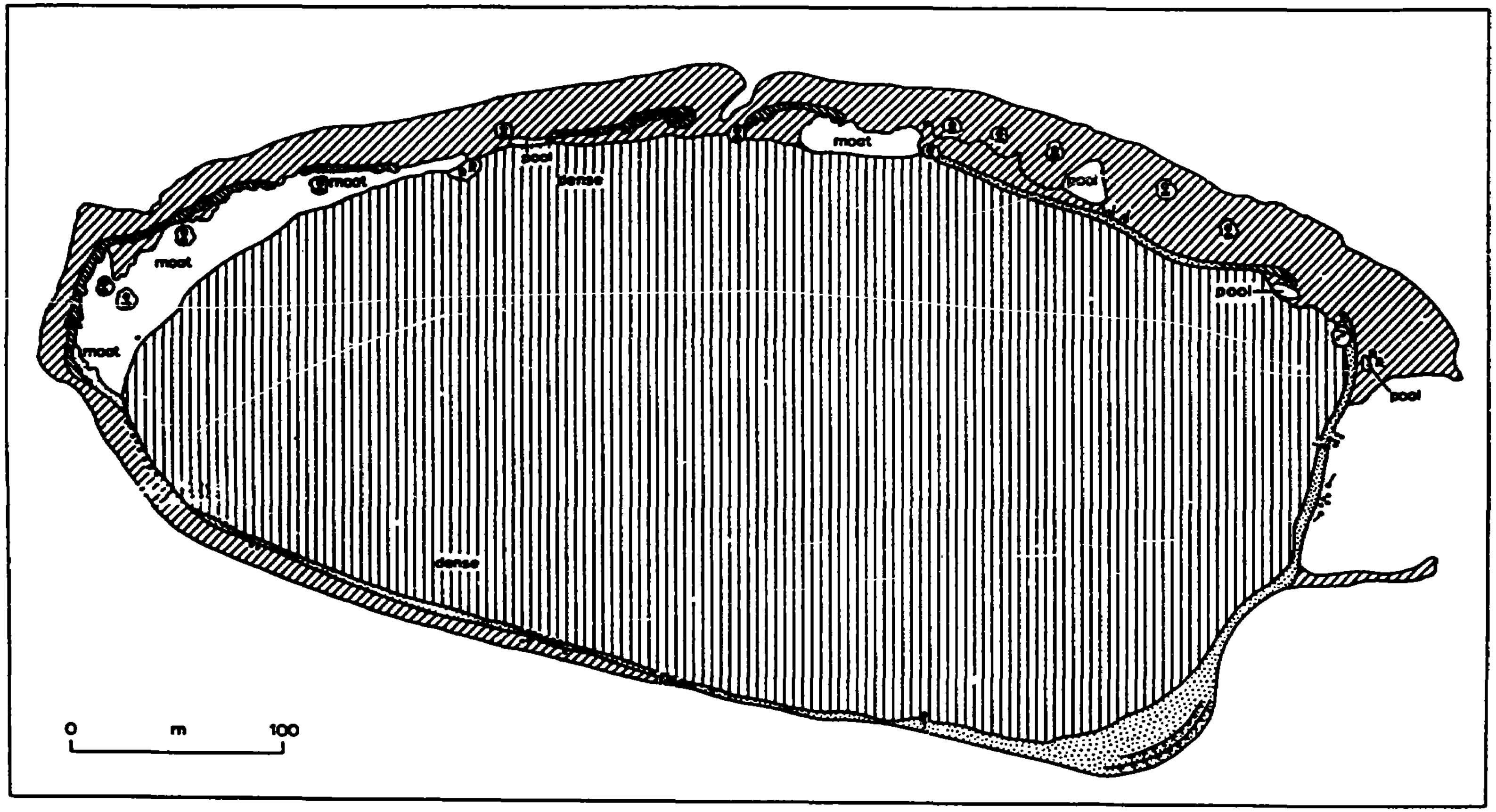
Air Kecil

c.



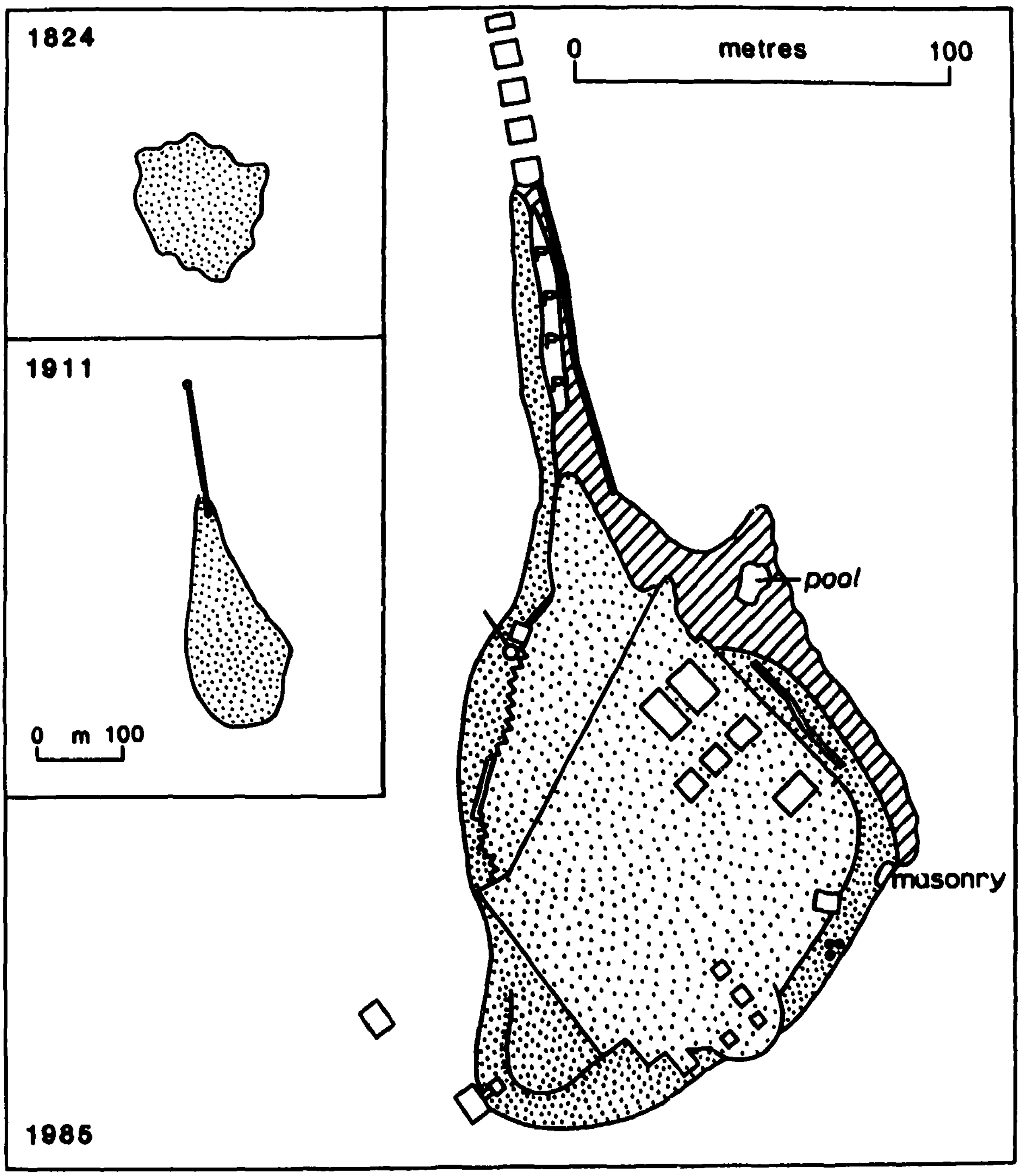
Bidadari (Sakit)

d.



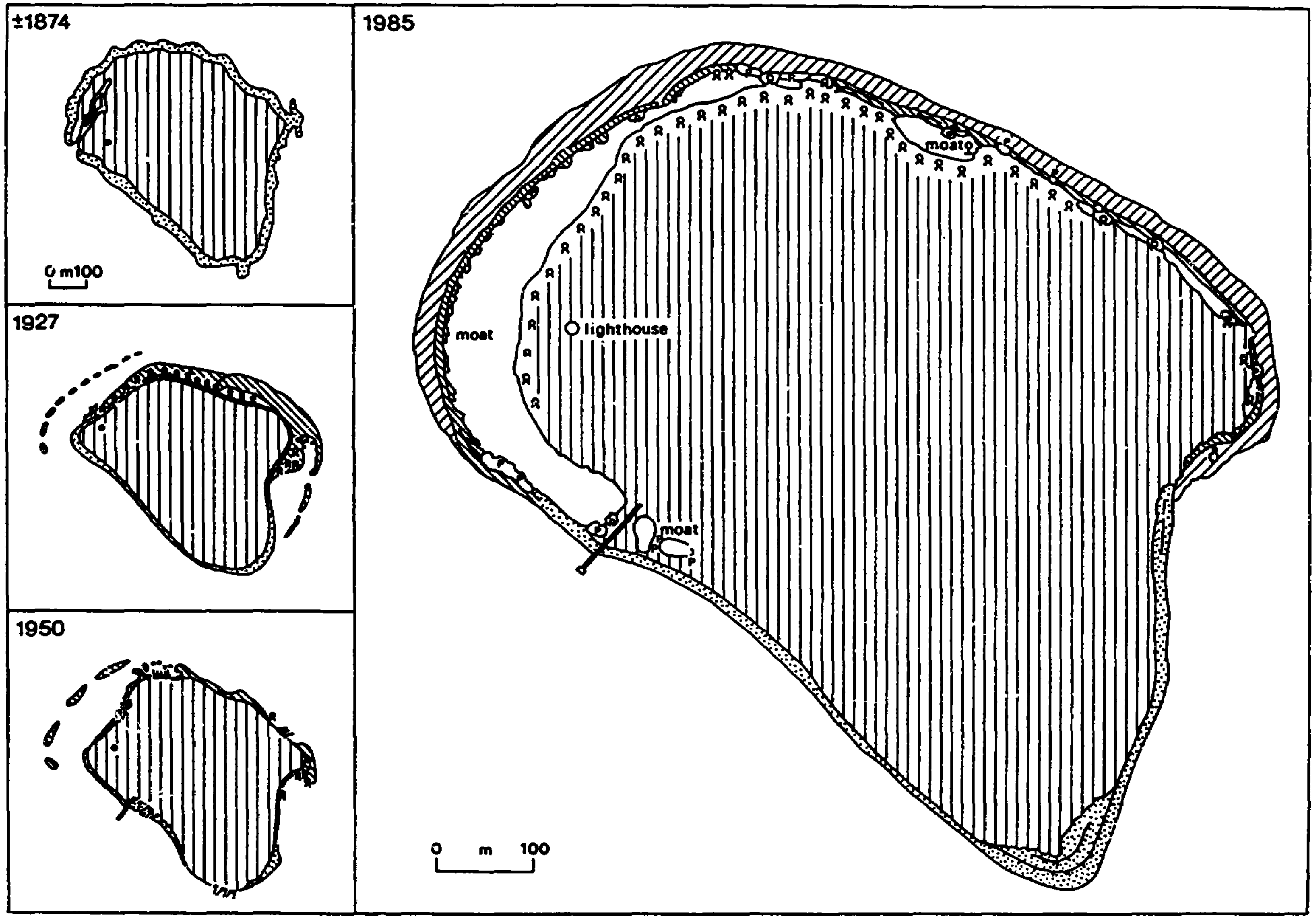
moat
moat
moat
moat
moat
pool
pool
pool
pool
dense
dense
0 m 100

Bokor



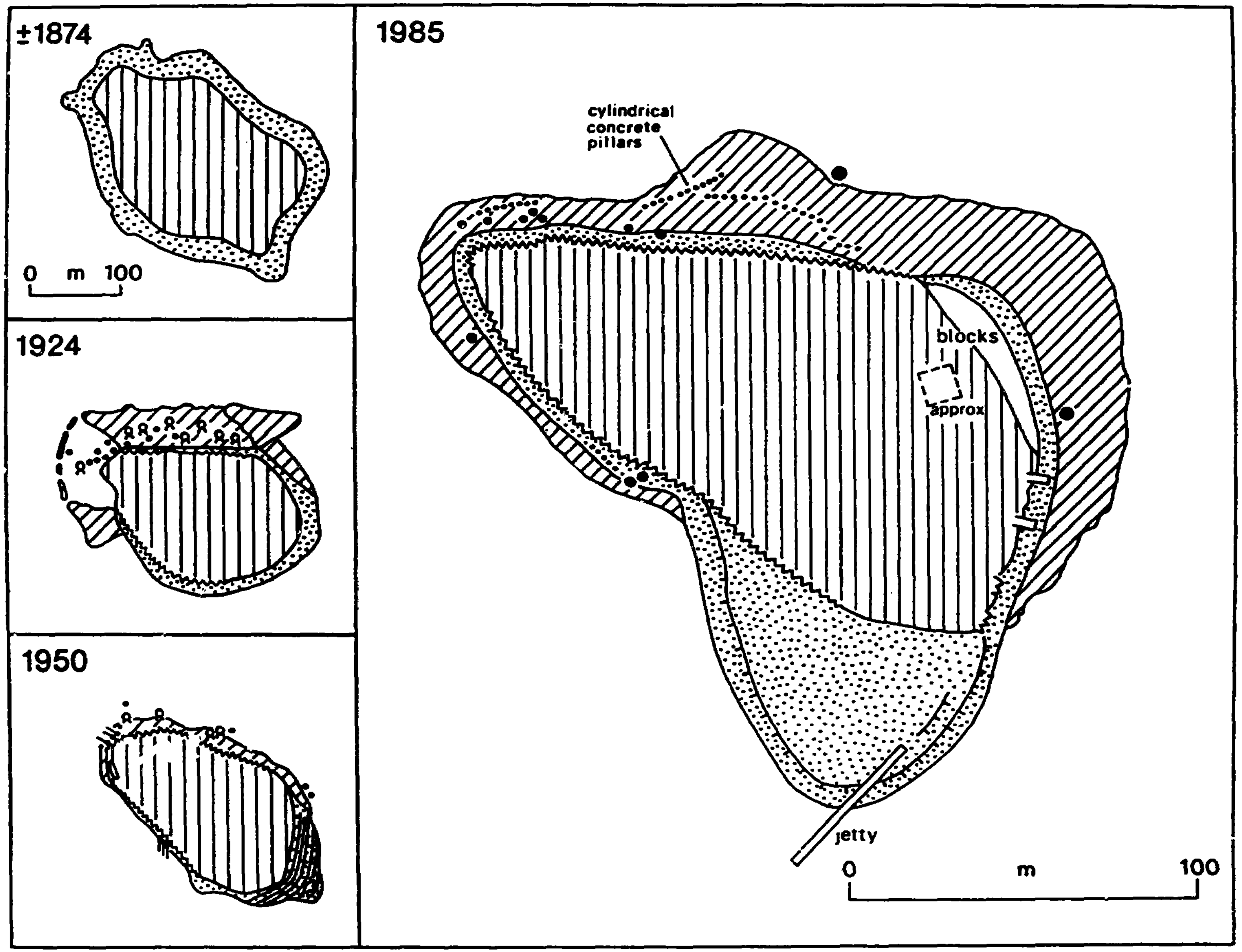
Cipir

f.



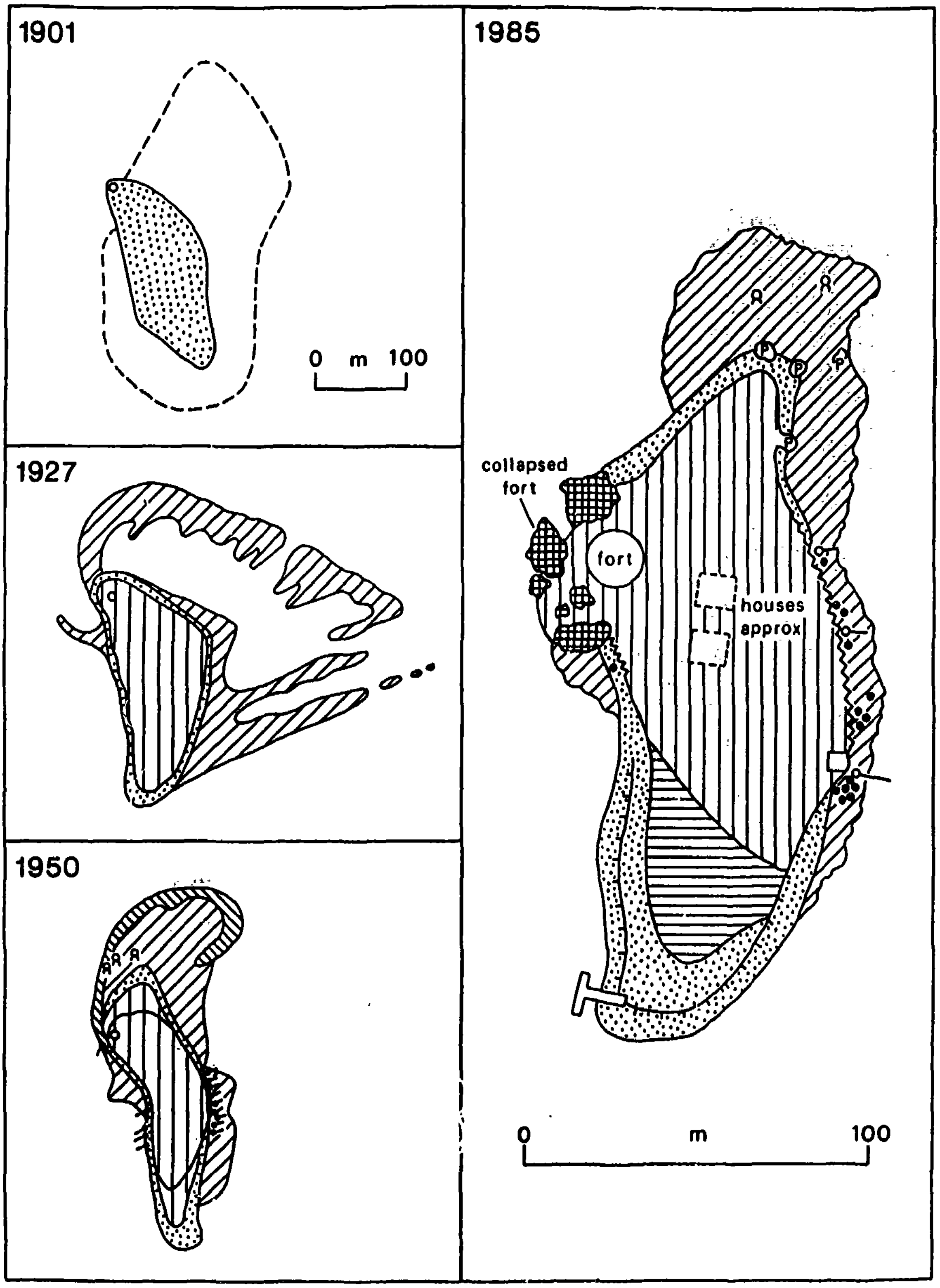
Damar Besar

g.



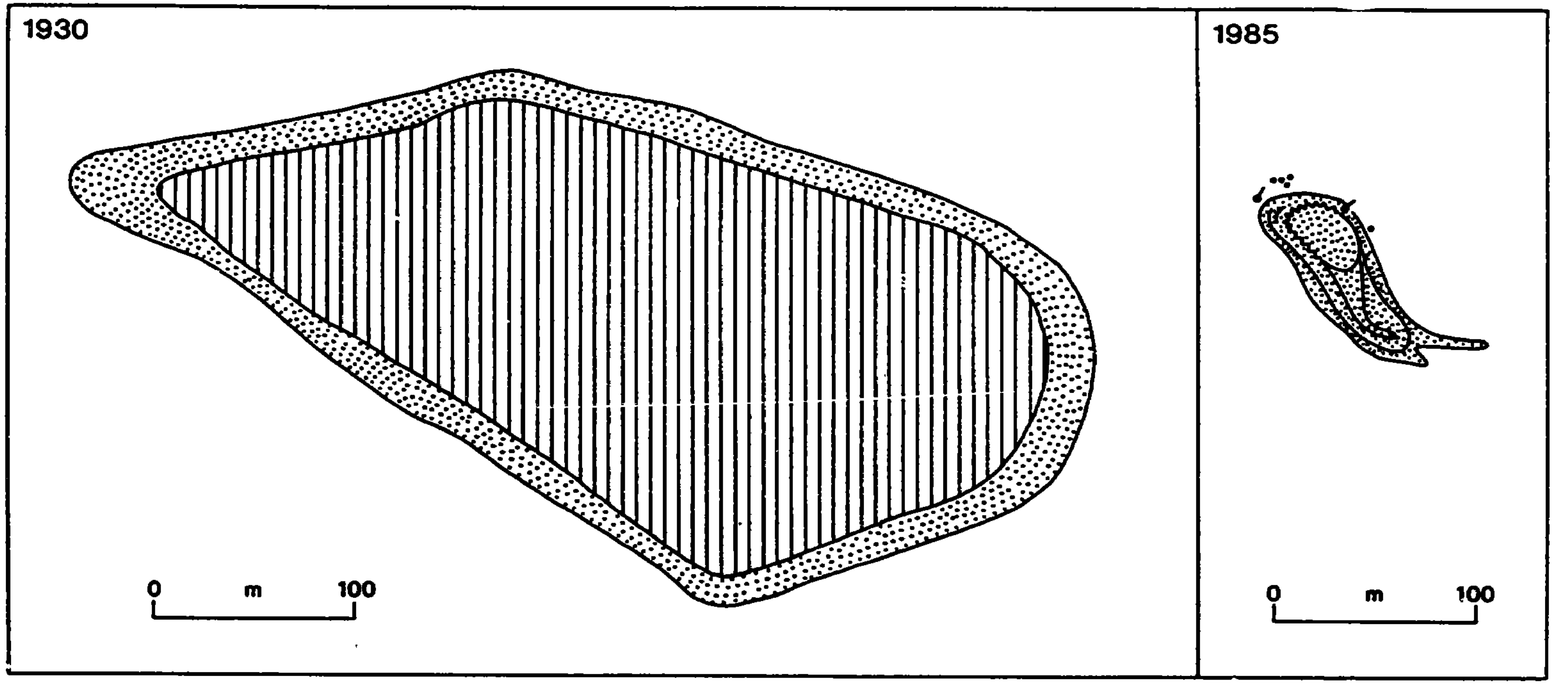
Damar Kecil

h.


1901
0 m 100
1927
1950
1985
collapsed fort
fort
houses approx
0
m
100

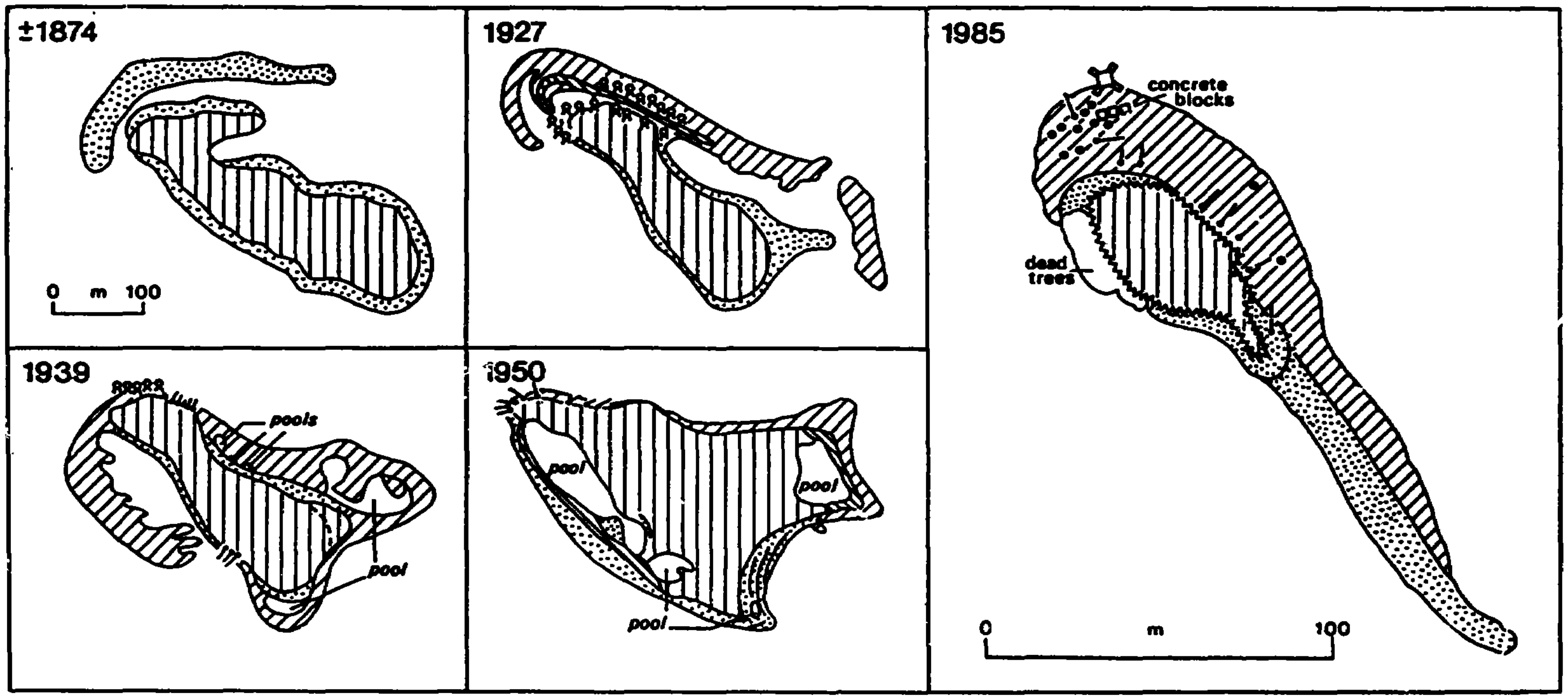
Kelor

i.



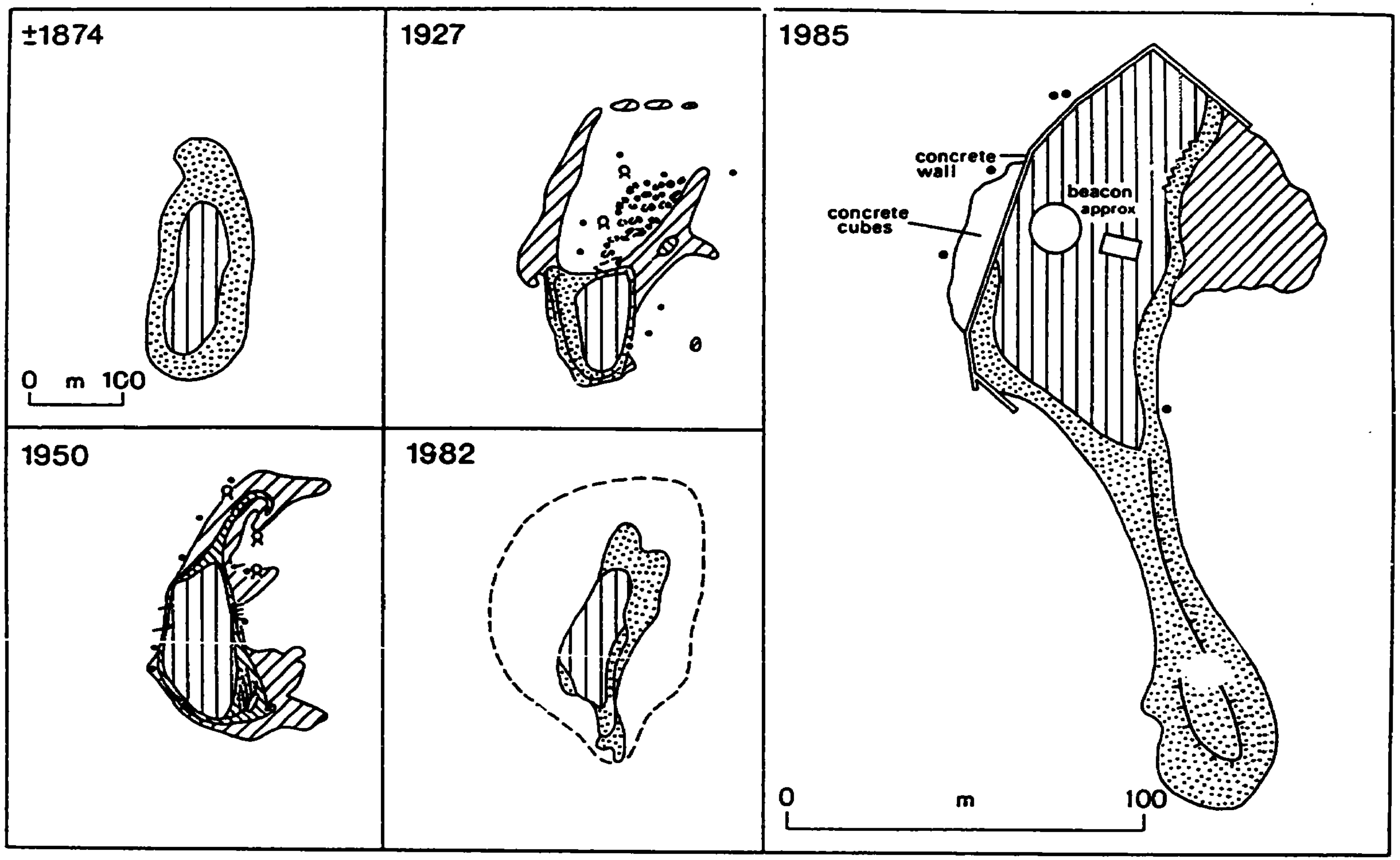
Dapur

j.



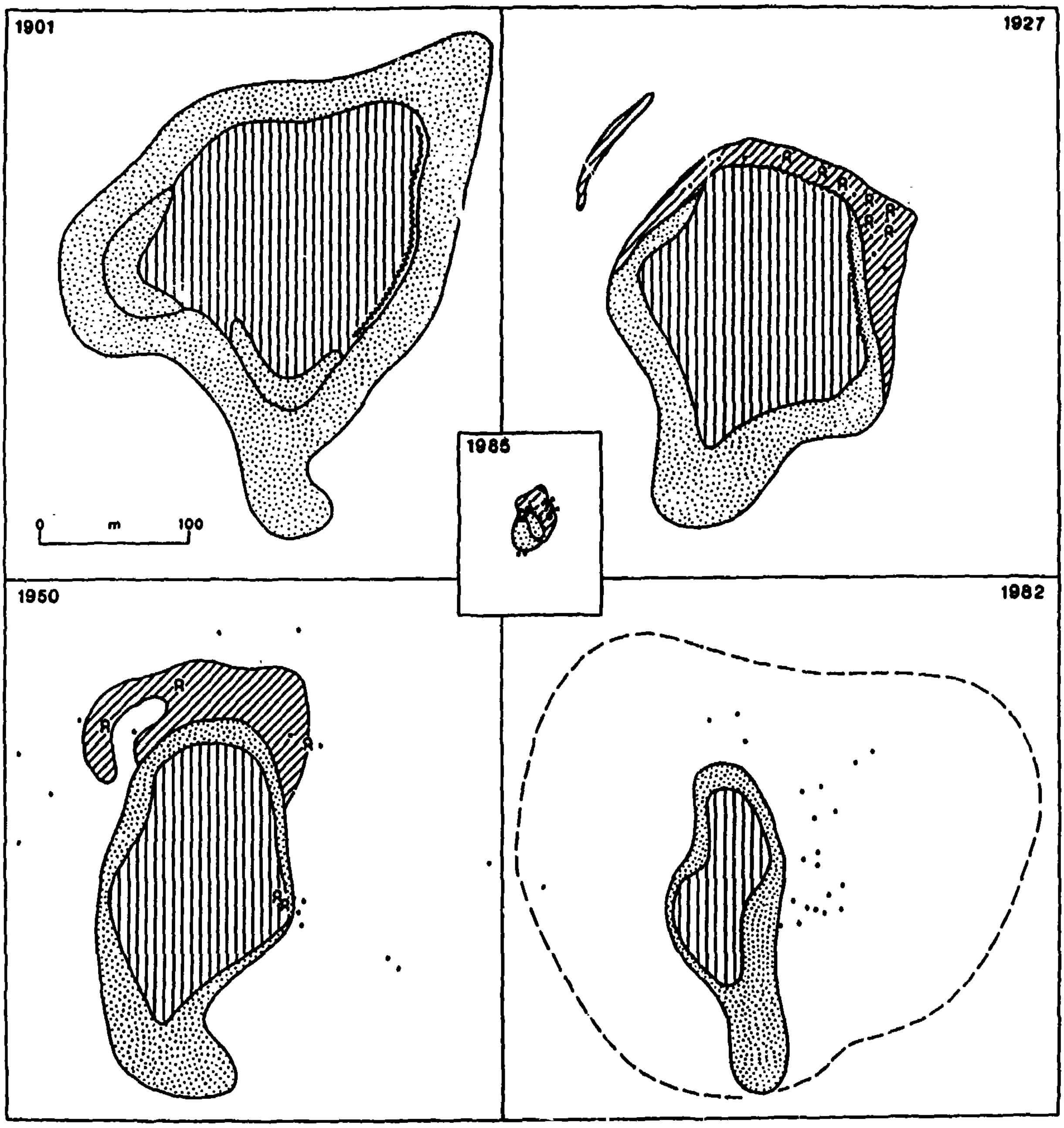
Nyamuk Besar

k.



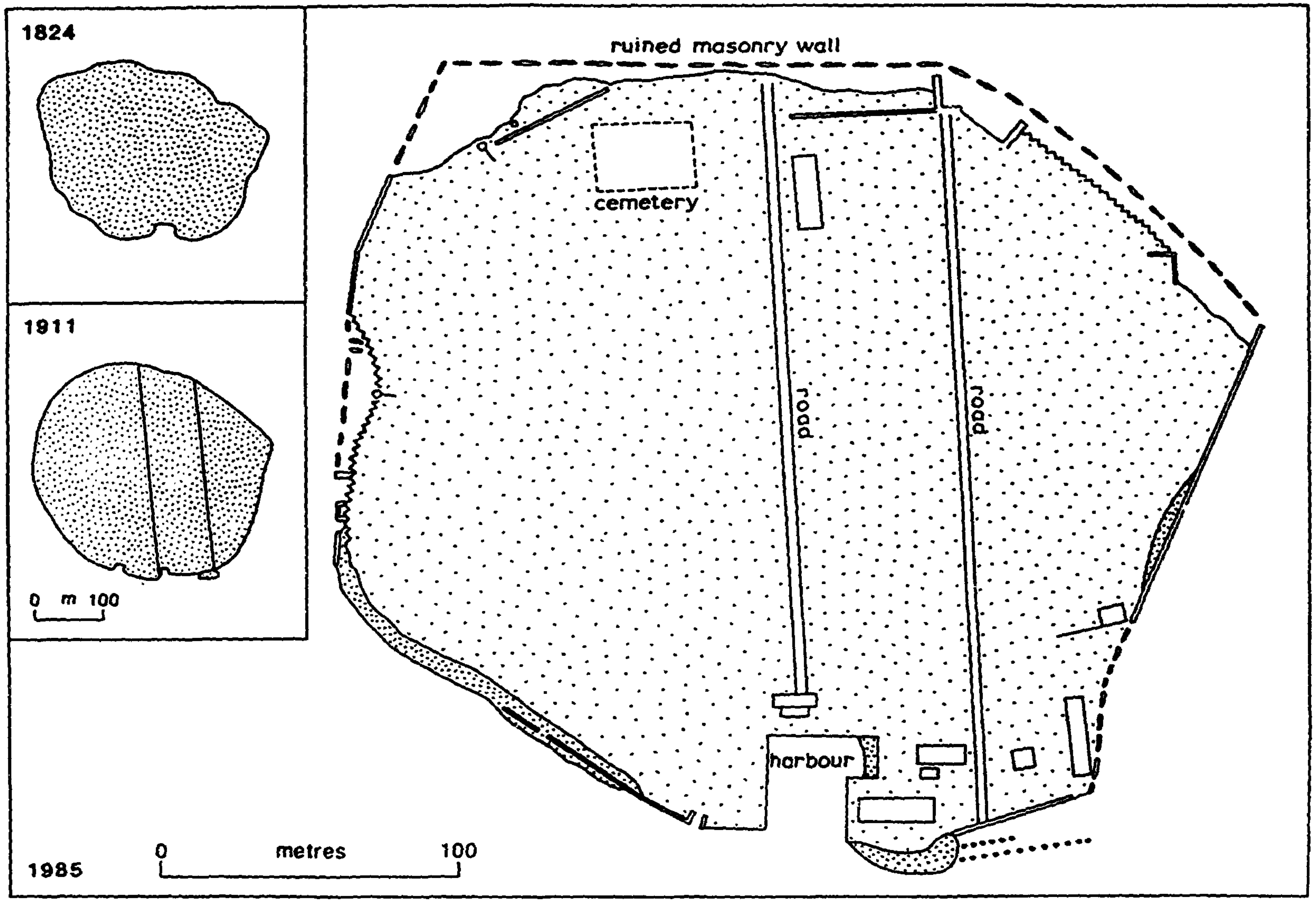
Nyamuk Kecil

I.



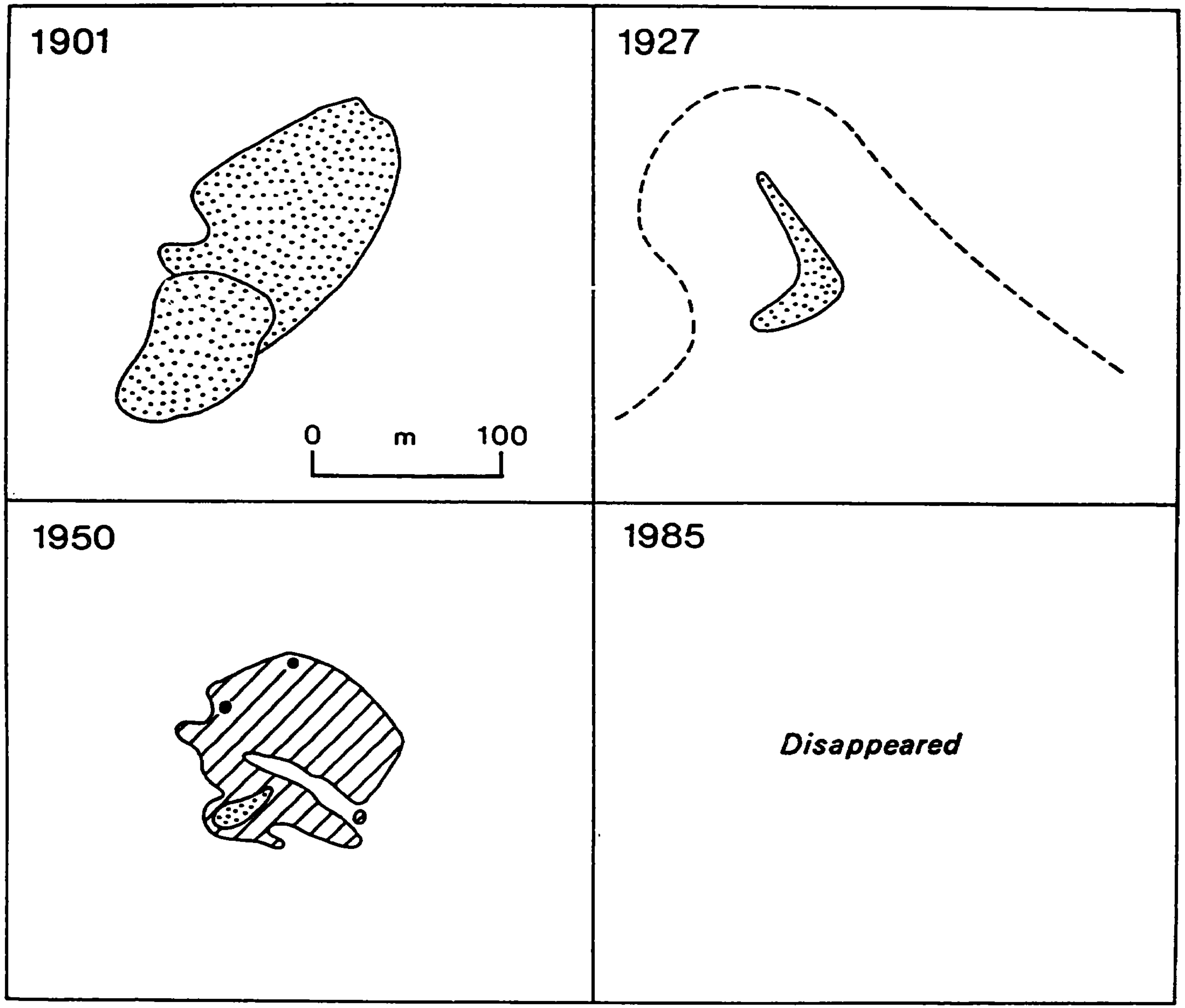
Ubi Besar

m.


1824
1911
0 m 100
ruined masonry wall
cemetery
road
road
harbour
1985
0 metres 100

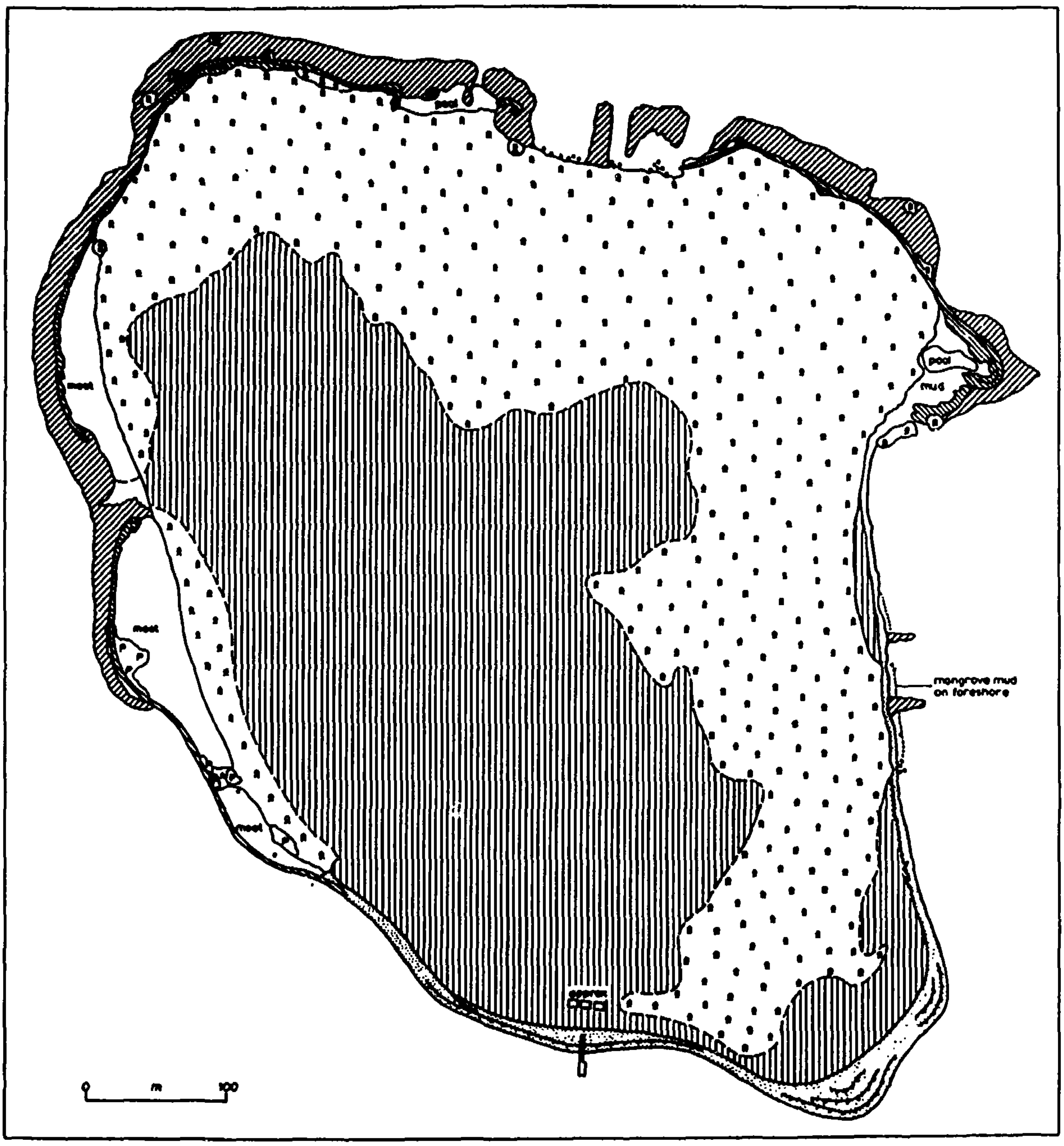
Undrus

n.



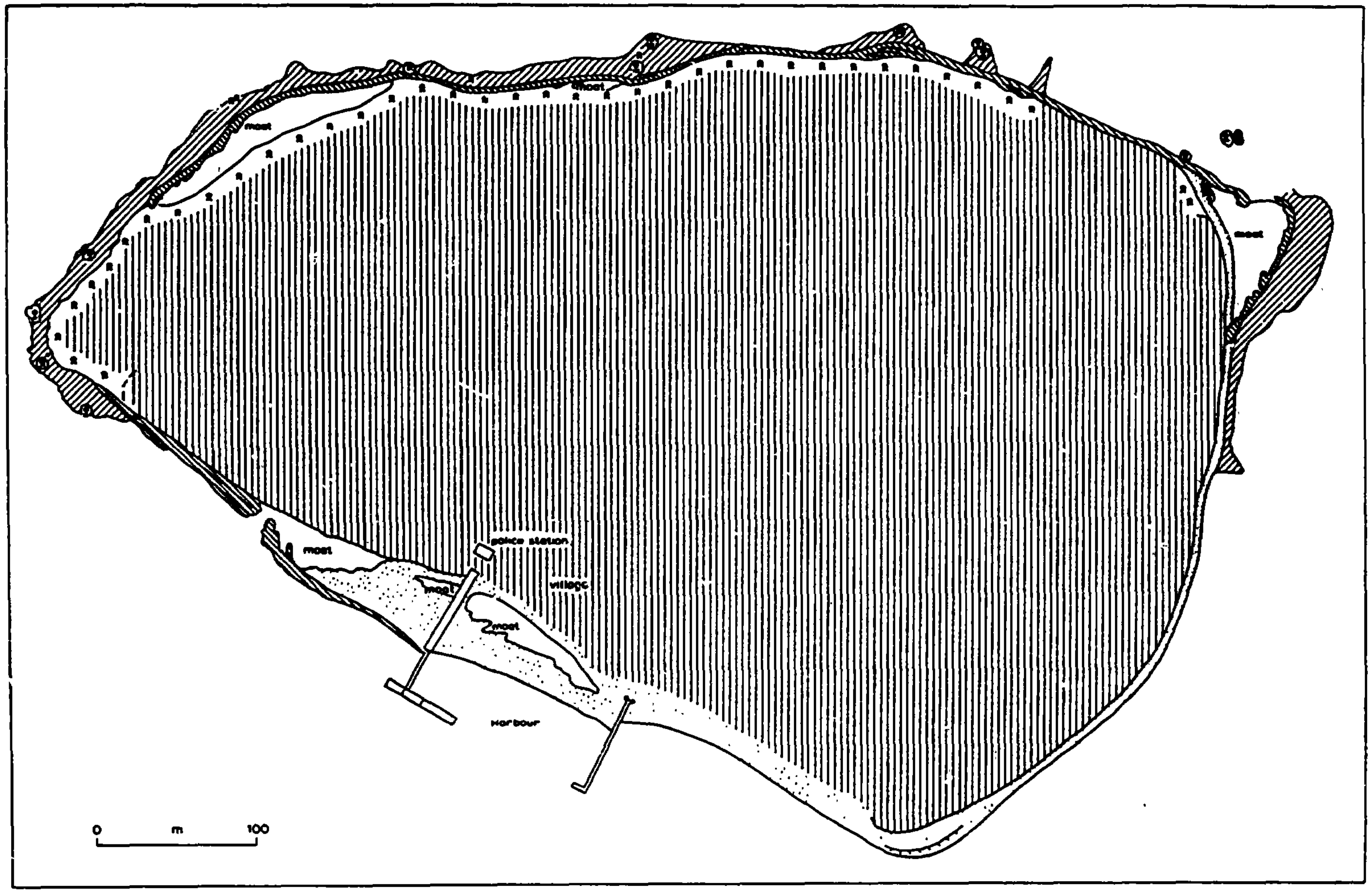
Ubi Kecil

o.



Rambut

p.



Untung Jawa

CHAPTER EIGHT

STUDIES IN THE ASSESSMENT OF CORAL REEF ECOSYSTEMS

Lyndon M. de Vantier
Australian Institute of Marine Science
Townsville, Queensland
Australia

Introduction

Overall aims of the program

Pressures on coastal marine resources from such diverse human activities as fishing, agriculture, industry, tourism and recreation are steadily increasing. Without careful management, the combined effects of these activities may result in depletion or destruction of these resources.

Dahl (1981) outlines some of these effects as increases in turbidity and siltation, abnormal inputs of nutrients and organic matter, pollution from toxic chemicals and oil, thermal loading, alterations to freshwater runoff, changes in water circulation and wave exposure, direct physical damage and breakage, and the selective removal of organisms or system components producing population imbalances and possibly interfering with nutrient cycling.

Natural phenomena can also induce significant impacts upon the coastal marine environment. Such perturbations may be caused by both abiotic and biotic factors. The major abiotic influences include the climatic forces of severe tropical storms. Cyclones, for example, can generate extreme winds producing heavy swell and rainfall conditions, occasionally interacting with extreme tidal fluctuations. The degree of damage caused by such storms is generally related to their position and intensity. Similarly, biotic factors can operate over a range of scales from individual interactions (such as competition for space between adjacent corals) to the relatively large scale effects of population fluctuations which may produce major changes in the composition of the system.

For example, a previous investigation by Sukarno and Harger (unpubl.) has demonstrated significant trends in coral reef community structure, within the Pulau Seribu island group, along a pollution gradient out of Jakarta Bay. With pollution and population pressures increasing within this region, research enabling description of the current state of the ecosystem, as a base-line to monitor man-induced or natural changes through time, should be considered of importance. This conclusion supports Dahl's (1977) earlier proposal that there remains an immediate need for information on coral reef regions on which to base environmental management decisions. Considering the management of coral reefs, which are generally large, complex and poorly understood, Bradbury et al. (1983) proposed a strategy that involves the application of heuristic (self organizing) tools to develop models for explanation, prediction and control. This report describes the development and application of a technique designed to provide a suitable data base from which such models may be built, and which will act as a base-line in the continued monitoring and management of specific reefal areas.

History of development

There has been some controversy in the literature (Gray 1976, Dahl 1977) concerning the value of base-line surveys in that previous surveys have "... often concentrated on the most easily sampled rather than most significant organisms, have been too small in sample size or area to encompass random variability, have been used to support conclusions based on inadequate evidence, and have been unable for lack of a theoretical base to account for subtle changes". While stating these criticisms, Dahl (1977) provides evidence supporting the use of reef survey techniques. As many coral reef organisms leave permanent traces of their existence in skeletal deposits, the reef's structural formation can provide long term evidence of environmental changes. Other reefal biota, such as the algal and fish populations, are more ephemeral, changing in response to relatively short term variability in their environment. These, and other factors discussed below, suggest that simple monitoring approaches may be useful in describing the dynamics of coral reef habitats.

While several investigators have examined community structure through elucidating the use of space by the major benthic groups (Barnes et al. 1971; Laxton 1974; Benayahu and Loya 1977; Drew 1977), the majority of coral reef research to date has been aimed at particular taxonomic levels. Such investigations generally do not provide information about the broad scale processes of community structure. The complexity of the reefal system, often compared to that of tropical rainforest (Connell 1978) suggests that any attempt at understanding the structural typology should encompass the entire benthic community, rather than particular taxa.

However, the structural and taxonomic heterogeneity of coral reef systems makes this task particularly difficult, with few workers capable of identifying all specimens of any one phylum, let alone the entire benthic community.

Webb and co-workers addressed a similar problem in terrestrial plant ecology with their pioneering rainforest studies of the 1960's and 1970's: "... in those areas where survey is most needed the flora is both at its richest and least known, trained observers are needed to collect the data, and identification of the species concerned becomes a major task" (Webb et al. 1970).

This difficulty is further compounded, in reefal ecosystems, by the great morphological plasticity of certain species, whose phenotypes can vary markedly when exposed to different environmental conditions (Veron and Pichon 1976; Bergquist 1978; Veron and Wallace 1984). Bergquist (1978) for example, discussing sponge taxonomy, noted that most early systematic or morphological research underlined the great plasticity of sponges in response to local and geographic environmental variables. Almost all attributes of structure were considered to vary within wide limits, making description and definition of species a specialist task. Because so many features of sponge morphology are suspected of variation, unrelated to genetic differences, the choice of characteristics to be used in delimiting major systematic categories is particularly difficult.

Furthermore, Done (1983), discussing coral zonation, cites examples from the Great Barrier Reef to demonstrate that the high degree of species overlap between topographic zones makes coral community definition on the basis of species composition difficult. Growth forms, however, are more distinctly zonal in their distribution. Ubiquitous species tend to adopt different growth forms in different zones with the diverse hydrodynamic, photic and sedimentary enviornments favouring different morphologies (Morton 1974).

The analogous problems of rainforest classification prompted Webb et al. (1970) to devise a classificatory technique based on structural attributes. The history of the application of structural or morphological characters to vegetation analysis is reviewed by Webb and co-workers (1970) and briefly summarized by Bradbury et al. (in press): "In botany, the use of morphological characters to describe vegetation is as old as plant geography itself. ...Early workers were content to use any characters they felt to be informative, and were aware that taxonomic considerations could not be entirely avoided ... Today it is usual to accept any set of informative characters, commonly termed "physiognomic-structural".

Previous applications

Recognizing the similarities between the quantitative classification of coral reef and rainforest community structure, Bradbury, Loya and Reichelt have adapted Webb et al.'s technique to the reefal system, and it is their classification scheme (Reichelt et al. in press) that forms the basis of this study: "Life form categories were used, rather than species level data, for several reasons. Coral community patterns have been demonstrated previously in a quantitative study of taxonomic groupings above the species level (Bradbury and Loya, 1978) and a strong relationship between morphological form and ecological function has been shown for algal assemblages (Littler et al. 1983)".

As surveys that aim to monitor the state of reefal ecosystems through time may be limited by climatic and logistic constraints, particularly at isolated and exposed locations, research of this type should be rapid and simple (Dahl 1977). Further, to allow for the spatial and temporal patchiness of reef communities, relocatable sites encompassing relatively large areas of reef should be examined through time.

Recognizing these constraints, a line transect technique (after Marsh et al. 1984), using a classification system based on structural attributes of life forms, was chosen. This method was economical underwater, being rapid, easily undersood by trainee observers, and requiring no cumbersome or elaborate equipment (Dahl 1977).

The application of this technique to large scale surveys may prove advantageous in that coral reefs all over the world share a common 'coral reefness' despite the fact that they may share few architectural species in common (Stehli and Wells 1971). Therefore analyses of community structure based on species attributes may illustrate the differences between reefs rather than their similarities (Bradbury et al. in press). Whereas analyses based on life form structural attributes should facilitate comparisons of community structure across a world scale (May 1976; Bradbury et al. in press).

To this purpose, the technique is currently being tested by Loya and co-workers in the coral reefs of the Red Sea (R. Reichelt, pers. comm.), is being used to survey reefs throughout the entire GBR region (AIMS Crown of

Thorns study, P. Moran, pers. comm.), and has here been applied in the Pulau Seribu reefs off N. Java, thereby facilitating comparisons of reef community structure among geographic regions.

Standardization and Application of Techniques

The theoretical basis and history of application of the line transect technique employed in this study is briefly reviewed by Marsh et al. (1984): "The method has been long established in terrestrial plant ecology (Greig-Smith 1964), and has now become a standard sampling technique for all sessile and sedentary organisms (Southwood 1966; Pielou 1977)".

In the field of coral reef research, Loya and Slobodkin (1971) and Loya (1972) first applied this line transect technique in studies designed to examine community structure of hermatypic corals in the Red Sea. The method is generally used to estimate the areal density of different types of organisms. This is achieved by transecting the research area and measuring the points of intersection of these organisms with the transect line. "Since the proportion of the transect lying over the (organisms) is an unbiased estimator of the fraction of the total area covered by these (organisms), irrespective of the shapes ..., the estimates of areal density may be derived directly" (Marsh et al. 1984).

This technique allows the calculation of percentage cover and total number of occurrences per transect of the organisms under investigation; in this case, life form attributes of the macro-benthos. The codes used to represent benthic community components are listed in Table VIII.1. These characters were developed from an initial set used by Bradbury and Young (1981) to examine coral community structure on Heron Island reef, Capricorn Group, GBR.

For this investigation, a list of 27 biotic and abiotic attributes, designed to cover 100 percent of the benthic topography of the study area, was prepared. While these attributes are morphologically based, several also possess a taxonomic element, as demonstrated by the "*Acropora* branching" category, for example. "The *Acropora* categories were included ... because of the very high diversity and abundance of this genus in the Indo-Pacific as a whole (Veron and Wallace 1984)... These categories are directly comparable to the physiognomic-structural categories used in plant geography (Webb et al. 1976)" (Reichelt et al. in press). For world scale surveys, however, an open-ended list would be preferable, to allow for local benthic variability. An example of such a system is cited by Webb et al. (1970) for rainforest community surveys.

It was determined to use a stratified sampling technique designed in accordance with Loya's (1978) conclusions that maximum accuracy may be achieved by stratified random sampling of coral reef communities. The reef area is divided into a number of subdivisions and several random samples taken within each. To allow for local tidal variability, specific transect depths were determined using low tide depth as datum with sites established 1 and 3m below this depth. The selection of these transect depths was influenced by logistic constraints allowing the use of both snorkel and SCUBA equipment, often a necessity where air supplies are uncertain.

Table VIII.1. List of attributes and respective codes used to classify the reefal benthic community.

Attribute description			Code
Scleractinian corals	- *Acropora*	*Acropora* branching	ACB
		Acropora tabulate	ACT
		Acropora encrusting	ACE
		Acropora submassive	ACS
	- non-*Acropora*	Coral branching	CB
		Coral massive	CM
		Coral submassive	CS
		Coral encrusting	CE
		Coral foliose	CF
Non-scleractinian corals			
	Soft corals		SC
	Gorgonians		GO
Other fauna	*Acanthaster planci*		OTA
	Anemones, Ascidians, Zoanthids, etc.		OT
	Sponges		SP
Algae	Algal Assemblage		AA
	Turf algae		TA
	Coralline algae		CA
	Turf-coralline algal areas		TA/CA
	Cyanophytic film algae		BFA
	Other film algae		FA
	Macro-algae except *Halimeda*		MA
	Halimeda		HA
Abiotic components	Sand		S
	Rubble		R
	Sand-rubble mixture		S/R
	Silt		SI
	Recently dead coral		DC

The field technique required the placement of a plastic metric tape measure, positioned by SCUBA or snorkel divers, along various depth contours at sites on reefs of the Kepulauan Seribu, and islands in the Bay of Jakarta.

Where safe diving practice allowed, 3 replicate transect lengths of 30m were sampled.

Groups of divers, moving along the transect, noted on waterproof paper the measurements of intersection of each benthic life form with the transect tape, generating a list of attribute codes and corresponding points of intersection at each site. These data were later transferred into the D-Base III management system of an IBM personal computer for storage and statistical analysis, with the initial results presented in this report.

It was proposed to initially survey, wherever possible, the North reef slopes on these reefs. The N reef sites were chosen for their comparatively high coral cover (Sukarno, pers. comm.), and to enable ease of statistical comparability between reefs.

Once sites were selected, their locations were noted on aerial photographs and nautical charts, to facilitate repeatability of surveys.

Efficiency of the field technique

Diving practice

The achievement of research objectives should not compromise the safety or health of the personnel involved. Prevention of problems in the application of the technique relate to safe SCUBA diving practices, and are generally obvious to the qualified diver. Several dives may be conducted each day necessitating dive planning in accordance with repetitive dive table no-decompression limits. Using low tides as datum (0m), tide height was added to the required depth contour to determine actual transect depth. As the accuracy of depth gauges was found to vary amongst instruments, regular testing and recalibration is recommended.

The direction in which the tape is laid should be determined by the strength of currents at the transect site. However, the gradations of some tapes, which are marked on one side only, facilitate reading in only one direction. This may not correspond to local current conditions. If possible, avoid using such tapes, and allow dives to proceed up current in accordance with safe diving practice. It is recommended that divers laying the tape refer to a depth gauge, as it was found that depth fluctuations of 5m may occur.

Placement of the transect tape

The benthic topography of the survey site may provide difficulties in the placement of the transect tape. This apparently simple task embodies many of the possible sources of error encountered in the field technique.

By far the greatest difficulty in the application of a 1 dimensional line transect technique lies in the fact that straight lines or smooth surfaces are rarely encountered in the 3 dimensional space of coral reefs (Pichon 1978; Bradbury and Reichelt 1984). This is particularly true of reef slopes where life forms may occupy several levels or strata (Pichon 1978). Such unevenness introduces several problems. For example, when the tape is laid, it may intersect the basal attachments of certain life forms, particularly those with stalked or tabulate morphologies such as soft corals, gorgonian or plate corals. Consequently, the percentage cover of these life forms may be underestimated. To overcome this situation, the tape should be positioned to follow the outline or upper stratum of benthic cover.

However, due to the unevenness of the benthos, the tape may thereby be positioned away from lower strata life-forms located in gaps between upper strata forms. If there is any appreciable distance separating the tape from the reef surface, parallax error and excessive movement may reduce the accuracy of measurements. It is therefore important that the tape is attached securely to the reef face. Stainless steel hooks or diving weights may be used to achieve this objective.

Life form identification

This line transect technique is designed for the use of non-specialist observers. Recorders should quickly acquire knowledge of the benthos of the areas under investigation, to minimise any difficulties in the correct identification of life forms. Such problems may arise from the variations in shape of scleractinian corals, where differentiation between foliose and encrusting or branching and submassive forms may prove difficult. Similarly, the fern-like stinging hydroid, Aglaeophenia sp., may be wrongly recorded as a macro-alga.

There are potentially many instances where incorrect identification may occur. However, initial comparisons of data sheets from duplicated sections of transect, and group discussion of life forms encountered therein, rapidly improve and standardize identification of these categories. This initial difficulty may be further reduced by the use of life form photographs during the orientation period.

Further, we found that to retain the speed of the technique it was impractical to record repetitive, small scale (2cm or less) life form changes occurring over a large area. This occurs, for example, where turf-, coralline-, and macro-algae are interspersed over the substrate. As combinations of life form categories generally have proven unsatisfactory for analysis, a degree of rationalization is needed when determining the dominant life form along the transect section. This situation arises chiefly amongst the algal and abiotic components of the benthos whereas the major structural components, the stony corals, generally occur as specific colonies.

Rapidity of the technique

Time estimates are entirely dependent on the weather conditions at time of survey. Front reef sites, particularly at shallow depths, may prove difficult or impossible to work in onshore wind speeds greater than 15 knots. Sampling time per transect is also directly dependent on the benthic complexity of the survey site. For example, recently damaged reef areas may be surveyed more quickly than unaffected areas. Generally, areas of low life form diversity may be surveyed most rapidly. In these situations, 2 sites may be surveyed in 1 dive, however recording accuracy and diving safety may be reduced by loss of concentration, onset of hypotherma etc. during completion of the second transect. For this survey, we found that approximately 1 hour was required to complete 3 x 30m replicate transects.

Optimum use of underwater time may be achieved by providing set tasks to each team member. For example, it was found that the efficiency of the team was improved by employing the slowest recorder to position the transect tape.

For large scale surveys where research objectives require rapid monitoring, or are aimed at particular benthic community components, the speed of this technique may be further increased by:

(a) reducing the complexity of the life form attribute list (e.g. grouping the 3 soft coral, 4 sponge or 5 algal attributes into single categories);

(b) manipulating the list to place greater emphasis on those benthic components under investigation. Particular attributes may be altered to include more specific taxonomic or structural elements of the community. For example, some scleractinian coral categories may be modified to the species level;

(c) reducing the number of sites per reef to be surveyed;

(d) increasing the number of diver-hours allocated to the survey (i.e. increasing the number of personnel and/or sea time allotted); or

(e) developing more efficient data recording equipment such as electonic slates, allowing direct transfer to ship-board computers.

Data Management

Storage and access

On completion of this survey cruise, the accumulated data were input to the D-BASE III management system using a relational data base program developed by R. Reichelt and J. Neal. The input facility of this program allows data to be entered under the headings of reef name, date and site of collection, life form code and respective metric tape measurements, and calculates the corresponding lengths prior to displaying the input information for proof-reading, and storage. To ensure the security and fidelity of the data, this input file was copied onto a second floppy disc.

For large scale surveys, input procedure may be improved by the development of electronic slates to enable direct data recording in machine readable form. This procedure would allow the automatic transfer of data into shipboard microcomputers for short term storage on floppy disc prior to transfer onto in-house data management facilities.

Due to the relatively large amount of data that may be collected and analysed, it is necessary that adequate space for data storage and manipulation is available on the respective data base. Upon data input, preprocessing for either community or population level analyses may be achieved using the various extraction routines of the D-BASE III program. These routines sort data into subfiles under any of the input parameters outlined above, thereby facilitating analysis by reef, site, life form or date of collection. The data sets produced by these survey methods are ideally suited to storage and management by data base systems that fit the general relational model (e.g. Codd 1970).

Overall scope of analyses

In this exercise, initial data manipulations for each life form were based on the preliminary calculations of percentage cover and number of occurrences at each site. These analyses provide statistically valid information on the community structure of the sampled sites. This data will also act as the base-line of a time-series of investigations designed to monitor the state of these reef areas in relation to disturbance from natural and man-induced pressures. Such time-series data, may be used as a predictive tool in reef management.

The scope of this technique encompasses a variety of analytical tools, from quantitative descriptions of specific population dynamics and aspects of community structure, through multivariate analyses of spatial pattern within and between reefs, regions and on a world scale, to techniques of system modelling.

Line transect data has been traditionally used to determine the areal density of organisms. However, this data may also be used, for example, to derive information on spatial distributions from the transition sequence of organisms. Pielou (1977) has demonstrated how such data may be utilized statistically to investigate the segregation of species and Bradbury and Loya (1978) have used heuristic techniques on coral transect sequences to investigate patterns of zonation. Furthermore, Bradbury and Young (1981) have extracted the patterns of coral neighbours in a study of the effects of coral interactions (Marsh et al. 1984).

Marsh et al. (1984) demonstrated for certain population level studies (e.g. investigations of the population dynamics of target species of scleractinian corals during recovery after predation by Ancanthaster planci) that the data provide a statistically valid sample of cover, density and size frequncy distribution. These estimates are derived from a "double inegral transform" of the data, based on a mathematical model of the reef as a system of non-overlapping circles in the plane. By applying this methodology, estimates of life-history parameters can be made. Resurveying sites through time can thereby provide detailed descriptions of the population dynamics of sessile species.

Reichelt et al. (in press) have further expanded the technique to investigate the utilization of space and distribution of observable interactions of the sessile reef benthos by employing spatial (gap) analyses of the data. Further, previous studies by Bradbury et al. (in press) have demonstrated that multivariate analyses of reefal benthic life forms are as efficient as more discrete analyses of the corals, for example, in defining the broad scale community structure. Also, because of their more embracing data set, they may find 'hidden' components of that structure not revealed in more discrete analyses. To this purpose, the data management system will preprocess the data into the formats required by the multivariate analyses of the TAXON suite of programs, available on CSIRONET. As sites are resurveyed through time, these analyses should provide a powerful description of the system's trajectory.

This methodology may also be applied to elucidate spatial patterns from multiscale data. For example, Reichelt and Bradbury (1984) have compared community structure of coral reef benthos from the GBR, Red Sea and Caribbean at local scale, cross-reef and regional zone levels to investigate relations between local and larger scale spatial patterns.

Such analyses on multiscale levels enable comparison between geogrpahic regions. This provides the basis for the development of more powerful mathematical models for prediction and control in ecosystem management. To this purpose, Green et al. (1983) have applied Ivakhnenko's (1971) "Group

Method of Data Handling" (GMDH) heuristic approach to the reefal system in developing learning algorithms that derive"... polynomial models of extremely high degree and complexity. For benthic data from the GBR, GMDH models fit the data from which they are derived significantly better than regression models. Using GMDH, taxon abundances can be predicted, both within and between reefs" (Green et al. 1983). This method thereby may be applied as a tool for explanation in similar ways to many other multivariate procedures. Green et al. (1983) further conclude that: "Predictive models derived by GMDH or related methods also have many potential management applications. For example, from LANDSAT data they might be used to derive black-box estimates of parameters such as water depth, concentrations of pollutants, or sizes of crown-of-thorns starfish infestations. When used with time series data, models derived using GMDH can contribute to attempts to control particular aspects of a system".

Conclusions

In conclusion, then, we are dealing with substantial research and management objectives, in that:

(i) the system is large - analyses are needed which provide understanding over both local and global scales;

(ii) the system is complex - analyses are needed which acknowledge a diversity of data sources and interactions among components;

(iii) the system is poorly understood - techniques are needed which predict the system's behaviour in areas where data are missing (Bradbury et al. 1983). The techniques of data collection and analysis outlined in this report have been designed to fulfil these research objectives and to thereby contribute to our understanding and management of this important resource.

Acknowledgements

I wish to gratefully acknowledge the assistance of D. Johnson, G. Barnes and P. Daniel who were instrumental in the initial broad scale application of the technique and in the preparation of the relevant manuscript (AIMS publication No. xxx).

References

Barnes, J., D.J. Bellamy, D.J. Jones, B.A. Whitton, E.A. Drew, L. Kenyon, J.N. Lythgoe and B.R. Rosen (1971). Morphology and ecology of the reef front of Aldabra. Symposia of the Zoological Society of London 28: 87-114.

Benayahu, Y. and Y. Loya (1977). Space partitioning by stony corals, soft corals and benthic algae on the coral reefs of the northern Gulf of Eilat (Red Sea). Helgolander Wissenschaftliche Meeresuntersuchungen 30: 362-382.

Bergquist, P.R. (1978). Sponges. Hutchinson and Co., London.

Bradbury, R.H. and Y. Loya (1978). A heuristic analysis of spatial patterns of hermatypic corals at Eilat, Red Sea. American Naturalist 112: 493-507.

Bradbury, R.H. and R.E. Reichelt (1984). Fractals in ecology: methods and interpretation. Marine Ecology Progress Series 14: 295-296.

Bradbury, R.H. and P.C. Young (1981). The effects of a major forcing function, wave energy, on a coral reef ecosystem. Marine Ecology Progress Series 5: 229-241.

Bradbury, R.H., R.E. Reichelt and D.G. Green (1983). Explanation, prediction and control in coral reef ecosystems. III. Models for control. In "Proceedings of Inaugural Great Barrier Reef Conference" (Baker, J.T. <u>et al</u>., eds.) James Cook University Press, Townsville: 165-169.

Bradbury, R.H., Y. Loya, R.E. Reichelt and W.T. Williams (in press). Patterns in the structural typology of benthic communities on two coral reefs of the central Great Barrier Reef. Coral Reefs.

Codd, E.F. (1970). A relational model of data for large shared data banks. Communications of the Association for Computing Machinery 13, No. 6, New York: 377-387.

Connell, J.H. (1978). Diversity in tropical rainforest and coral reefs. Science 199: 1302-1310.

Dahl, A.L. (1977). Monitoring man's impact on Pacific island reefs. In "Proceedings Third International Coral Reef Symposium", Miami: 571-575.

Dahl, A.L. (1981). Monitoring coral reefs for urban impact. Bulletin of Marine Science 31: 544-551.

Done, T.J. (1982). Patterns in the distribution of coral communities across the central Great Barrier Reef. Coral Reefs 1: 95-107.

Done, T.J. (1983). Coral zonation: its nature and significance. In "Perspectives on coral reefs" (Barnes, D. ed.). Brian Clouston Publ., A.C.T.: 107-139.

Drew, E. (1977). A photographic survey down the seaward reef front of Aldabra atoll. Atoll Research Bulletin 193: 1-7.

Gray, J. (1976). Are marine base-line surveys worthwhile? New Scientist 29.4.1976: 219-221.

Great Barrier Reef Marine Park Act, 1975.

Green, D.G., R.H. Bradbury and R.E. Reichelt (1983). Explanation, prediction and control in coral reef ecosystems. III. Models for control. In "Proceedings of Inaugural Great Barrier Reef Conference" (Baker, J.T. <u>et al</u>., eds.) James Cook University Press, Townsville: 213-215.

Greig-Smith, P. (1964). "Quantitative plant ecology". Butterworths, London.

Ivakhnenko, A.G. (1971). IEEE Transactions on Systems, Man and Cybernetics, Vol. SMC-1, 364.

Laxton, J.H. (1974). Aspects of the ecology of the coral-eating starfish Acanthaster planci. Biological Journal of Linnean Society of London 6(1): 19-45.

Littler, M.J., P.R. Taylor and D.S. Littler (1983). Algal resistance to herbivory on a Caribbean Barrier Reef. Coral Reefs 2: 111-118.

Loya, Y. (1972). Community structure and species diversity of hermatypic corals at Eilat, Red Sea. Marine Biology 13: 100-123.

Loya, Y. (1978). Plotless and transect methods. In "Coral reefs: research methods" (Stoddart, D.R. and R.F. Johannes, eds.). UNESCO, Paris: 197-217.

Loya, Y. and L.B. Slobodkin (1971). The coral reefs of Eilat (Gulf of Eilat, Red Sea). In "Regional variation in Indian Ocean coral reefs" (Stoddart, D.R. and L.M. Yonge, eds.). Symposia of the Zoological Society of London 28: 117-139, Academic Press, London.

Marsh, C.M., R.H. Bradbury and R.E. Reichelt (1984). Determination of the physical parameters of coral distributions using line transect data. Coral Reefs 2: 173-180.

May, R.M. (ed.) (1976). Patterns in multispecies communities. In "Theoretical ecology: principles and applications" Blackwell, Oxford, 142-162.

Morton, J. (1974). The coral reefs of the British Solomon Islands: a comparative study of their composition and ecology. In "Proceedings Second International Coral Reef Symposium", Brisbane, GBR committee, 2: 31-53.

Pichon, M. (1978). Problems of measuring and mapping coral reef colonies. In "Coral reefs: research methods" (Stoddart, D.R. and R.E. Johannes, eds.). UNESCO, Paris: 219-230.

Pielou, E.C. (1977). "Mathematical ecology". Wiley, New York.

Reichelt, R.E. and R.H. Bradbury (1984). Spatial patterns in coral reef benthos: Multiscale analysis of sites from three oceans. Marine Ecology Progress Series 17: 251-257.

Reichelt, R.E., Y. Loya and R.H. Bradbury (in press). The use of space by the major benthic groups on Davies and Myrmidon Reefs, Great Barrier Reef. Marine Ecology P.S.N.Z.I.

Southwood, T.R. (1966). "Ecological methods". Methuen, London.

Stehli, F.G. and J.W. Wells (1971). Diversity and age patterns in hermatypic corals. Systematic Zoology 20: 113-126.

Veron, J.E.N. and M. Pichon (1976). Scleractinia of Eastern Australia. (Part I) Families Thamnasteriidae, Astrocoeniidae, Pocilloporidae. AIMS Monograph Series Vol. 1, Australian National University Press, Canberra.

Veron, J.E.N. and C.C. Wallace (1984). Scleractinia of Eastern Australia. (Part V) Family Acroporidae. AIMS Monograph Series Vol. 6, Australian National University Press, Canberra.

Webb, L.J., J.G. Tracey and W.T. Williams (1976). The value of structural features in tropical forest typology. Australian Journal of Ecology 1: 2-38.

Webb, L.J., J.G. Tracey, W.T. Williams and G.N. Lance (1970). Studies in the numerical analysis of complex rainforest communities. V. A comparison of the properties of floristic and physiognomic-structural data. Journal of Ecology 58: 203-232.

CHAPTER NINE

DISTRIBUTION, DIVERSITY AND ABUNDANCE OF REEF CORALS IN JAKARTA BAY AND KEPULAUAN SERIBU

H. Moll
Rijksmuseum Natuurlijke Historie
Leiden, The Netherlands

Suharsono
LON (LIPI)
Jakarta, Indonesia

Introduction

Early studies of the corals of the area include Umbgrove (1928, 1929, 1939), Verwey (1931), Hardenberg (1939) and Verstappen (1953). Umbgrove (1928) was the first to note the inhibitory effect of sediment on the coral life. At the mouths of the three major rivers affecting the bay (Cisadane, Citarum and K. Angke; see Figure 9:1) the effect of silt is complemented by the fresh water input. Already in 1927 he excluded the islands Kapal and Cipir (between Bidadari and the mainland) from his investigations because of anthropogenic influences, another factor gravely affecting the condition of coral reefs. In relation to the coral composition of the reefs Umbgrove (1928) recognised several zones ("facies") on the reef flat going from the shore to deeper water:

- the lagoonal *Montipora digitata* zone ("*M. ramosa*");
- the algal ridge ("Rhodophyceae");
- *M. foliosa* zone;
- sometimes an *Acropora aspera* zone ("*A. sarmentosa*");
- and finally a permanently submerged "rich reef".

The present study was a comparative one, not carried out to distinguish zones. Furthermore, a least the first four of Umbgrove's zones lie outside the range surveyed in the course of this work.

Umbgrove's paper of 1929 shows that the east monsoon has a much larger impact on the islands in the area than its antagonist the west monsoon. The former mainly affects the north to north-east side and the east to south-east side of these islands. This effect has largely diminished in the more sheltered Jakarta Bay.

Verwey (1931) studied the sedimentation by comparing bathymetric charts from the past. He derives a sedimentation rate of 1.5m in about 32 years. Verstappen (1953) further elaborates on the sediment input from the Java mainland, pointing out the large differences in silt transportation during the east and west monsoon. During the latter, 80% of all silt input by the Citarum is effectuated, most of which is transported by the prevailing westward currents in that period; the mainland cape U. Jawa shelters Jakarta Bay from most of the sediment from the Cisadane.

During the east monsoon with westward currents there is comparatively little sediment input into the bay, mainly from the Citarum. Effects of the K. Angke are mainly "felt" close along the shore of the bay (Kastoro 1977). Running through highly populated areas, it does however carry a large variety of pollutants (Hutagalung & Razak 1977; Thayib *et al*. 1977).

The use of scleractinian systematics in transect surveys (Loya & Slobodkin 1971; Loya 1972) has been widely practiced. Recent studies within the same area (Moll 1983, 1985) have demonstrated the usefulness of this technique to investigate the basic structure and condition of the reef as well as to make an inventory of the extant coral species and study distribution patterns.

Previous preliminary surveys of some of the islands near Jakarta (Harger & Sukarno 1985) indicated an increasing coral cover and better overall conditions of the reef going further off-shore. Therefore a large number of islands were studied at varying distance from the coast. In total 28 islands were surveyed in Jakarta Bay and the Thousand Islands. Figure 9:1 shows their position and the code of the transects made at these islands. This code signifies the relative distance to shore in east-west zones (first digit), and the north-south strip that islands are grouped into (second digit = longitude). These first two digits delimit a number of sectors on Figure 9:1 within which individual islands are distinguished by the third digit. Transects recorded at the shallower sites (see below) have codes ending with 0; those from deeper water end with 1.

Methods

Transects were always made at the north-eastern side of the island for sake of uniformity. Two sites were chosen there, one at depths between 1m and 1.5m and the other between 3m and 5m. At each of these sites three replicate transects of 30m were recorded, comparable in sampling intensity to the surveys made by the "life-form" group (see Chapter 8). In many cases a plastic tape measure was used since no chain was available. However, a chain clearly has the advantage of not being subject to water movement and this makes it more accurate and more random.

Total living cover (cov%), living coral cover (cor%), number of species (nsp) and number of colonies (ncol) were recorded under the transect line. The size of the individual colonies was registered as the vertical projection onto the transect line. By keeping in mind the growth form of certain species, their contribution to the actual surface of living coral in the area can be envisaged.

Results

The 193 species (belonging to 58 genera plus 6 sub-genera) recorded in the course of these investigations are listed in Table IX.1. Other checklists from the area include Sukarno (1977), Brown et al. (1983) and Suharsono & Kiswara (1984). The number of species presented here is lower than values presented for Sulawesi (Moll 1983) and Eastern Indonesia (Moll 1985). It should be noted, however, that the field work period of those studies was 17 months and 2 months respectively, whereas the present surveys were carried out within two weeks, leaving little time for intensive surveys of adjacent areas.

Transect values are listed in Table IX.2 as averages over the three replicates.

Key to Figure:

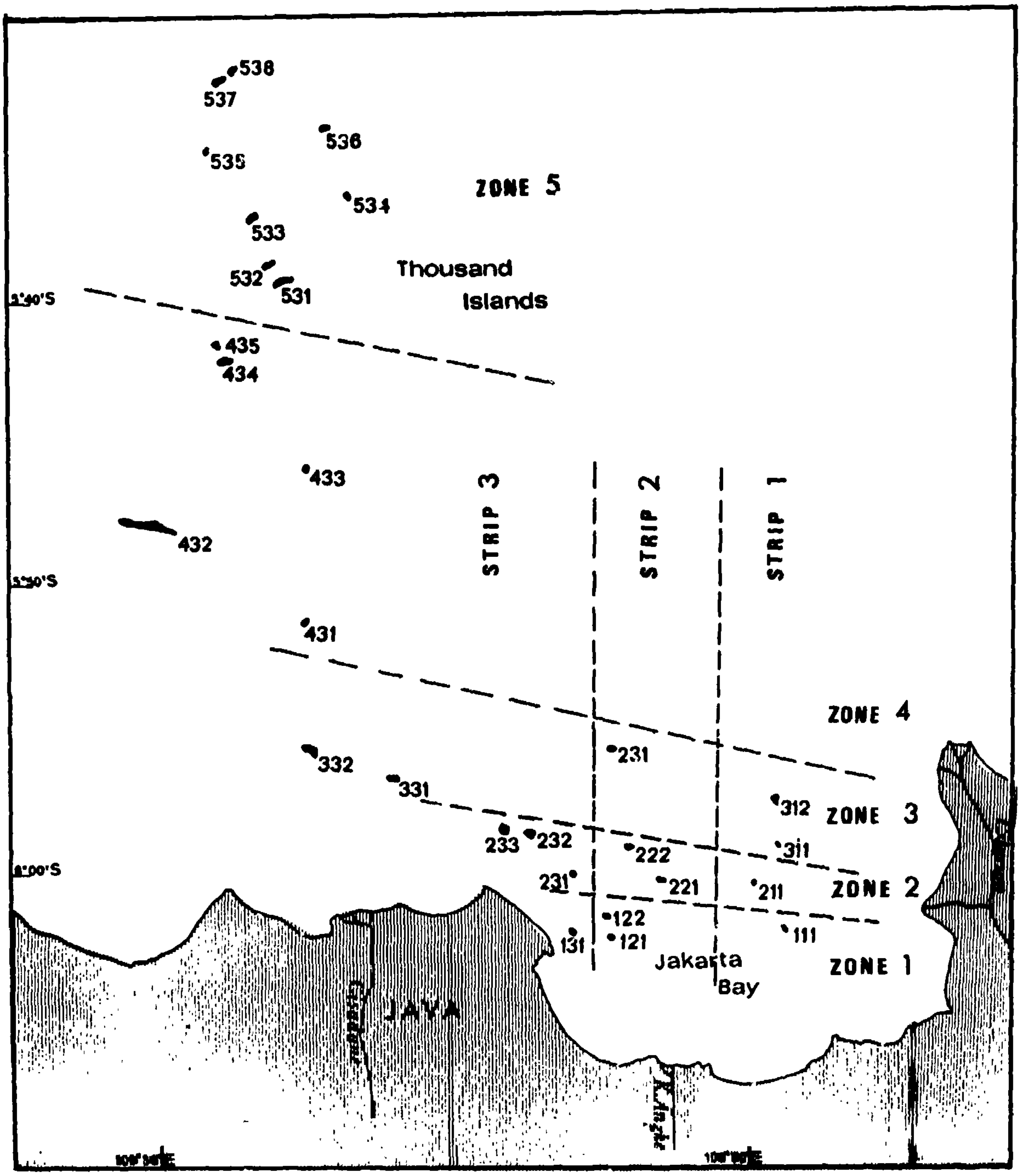


FIGURE 9.1 Map showing the island reefs surveyed in Jakarta Bay and the Kepulauan Seribu. Each site bears a code which shows the relative distance to shore in east-west zones (first digit); the north-south strip that islands are grouped into (second digit = longitude). The third digit distinguishes individual islands.

Table IX.1. Coral species recorded during survey. Asterisk indicates that species was also listed by Umbgrove (1928, 1939).

Species name	Species name
Acanthastrea echinata	Acrhelia horrescens
Acropora accuminata	Acropora aculeus
* Acropora aspera	Acropora brueggemanni
Acropora cerealis	Acropora clathrata
Acropora cytherea	Acropora danai
Acropora digitifera	Acropora divaricata
Acropora echinata	Acropora elseyi
Acropora florida	* Acropora formosa
Acropora gradis	Acropora granulosa
* Acropora horrida	Acropora humilis
* Acropora hyacynthus	Acropora latistella
Acropora longicyathus	Acropora loripes
Acropora microclados	Acropora microphthalma
Acropora millepora	Acropora nasuta
Acropora nobilis	* Acropora palifera
Acropora paniculata	Acropora polystoma
Acropora pulchra	* Acropora robusta
* Acropora sarmentosa	Acropora secale
Acropora tenuis	Acropora valida
Acropora vaughani	Acropora yongei
Alveopora spongiosa	* Astreopora myriophthalma
Barbattoia amicorum	Caulastrea echinulata
* Caulastrea tumida	Clavarina scabricula
* Coeloseris mayeri	Coscinaria columna
* Coscinaria exesa	Ctenactis crassa
* Ctenactis echinata	* Cyphastrea chalcidicum
* Cyphastrea microphthalma	* Cyphastrea serailia
Dendrophyllia fistula	* Diploastrea heliopora
* Echinophyllia aspera	* Echinophyllia echinata
* Echinopora gemmacea	Echinopora hirsutissima
* Echinopora horrida	* Echinopora lamellosa
Echinopora mammiformis	* Euphyllia glabrescens
Euphyllia ancora	Favia favus
Favia matthaii	Favia maxima
* Favia pallida	Favia rotumana
* Favia stelligera	Favia veroni
* Favites abdita	* Favites chinensis
* Favites flexuosa	Favites halicora
* Favites pentagone	* Fungia concinna
* Fungia danai	* Fungia fungites
Fungia horrida	Fungia paumotensis
* Fungia repanda	* Fungia scutaria
* Galaxea astreata	* Galexea fascicularis
Gardineroseris planulata	* Goniastrea aspera
Goniastrea edwardsi	* Goniastrea pectinata
* Goniastrea retiformis	* Goniopora columna
Goniopora lobata	* Heliofungia actiniformis
* Herpolitha trilinguis	* Hydnophora exesa
* Hydnophora microconos	Hydnophora rigida

Table IX.1 (continued)

Species name	Species name
Leptastrea pruinosa	* Leptastrea purpurea
Leptastrea transversa	* Leptoria phrygia
Leptoseris explanata	Lithophyllon undulatum
* Lobophyllia corymbosa	Lobophyllia hataii
* Lobophyllia hemprichii	* Merulina ampliata
Montastrea annuligera	Montastrea curta
Montastrea magnistellata	* Montastrea valenciennesii
* Montipora aequituberculata	Montipora crassituberculata
* Montipora digitata	Montipora efflorescens
* Montipora foliosa	Montipora hispida
Montipora hoffmeisteri	Montipora informis
Montipora monasteriata	Montipora nodosa
Montipora spongodes	Montipora stellata
Montipora tuberculosa	Montipora undata
Montipora verrucosa	* Mycedium elephantotus
* Oulastrea crispata	Oulophyllia crispa
* Oxypora lacera	* Pachyseris rugosa
* Pachyseris speciosa	* Pavona cactus
* Pavona clavus	* Pavona decussata
Pavona explanulata	* Pavona varians
* Pavona venosa	* Pectinia lactuca
Physogyra lichtensteini	* Platygyra daedalea
* Platygyra lamellina	Platygyra pini
Platygyra sinensis	Plerogyra sinuosa
* Pocillopora damicornis	* Pocillopora eydouxi
* Pocillopora verrucosa	* Podabacea crustacea
* Polyphyllia talpina	* Porites cylindrica
Porites lichen	Porites lobata
* Porites lutea	Porites nigrescens
Porites rus	Porites solida
Porites stephensoni	Porites vaughani
* Psammocora contigua	Psammocora digitata
Psammocora nierstraszi	Psammocora profundacella
* Sandalolitha robusta	Seriatopora caliendrum
* Seriatopora hystrix	* Stylophora pistillata
* Symphyllia radians	* Symphyllia recta
Symphyllia valenciennesii	Tubastrea aurea
Tubastrea diaphana	* Turbinaria peltata
Turbinaria reniformis	Favites rotundata
Goniastrea favulus	Acropora monticulosa
Acropora donei	Acropora diversa
Symphyllia cf recta	Herpetoglossa simplex
Acropora subulata	* Scapophyllia cylindrica
Acropora sp.	Goniopora catalai
Acropora rotumana	Acropora gemmifera
Acropora squarrosa	Acropora variabilis
Acropora listeri	Acropora dendrum

Table IX.2. Average values for cover (cov%), living coral cover (cor%), number of species (nsp) and number of colonies (ncol) for three replicate transects at shallow (1-1.5m) and deeper (3-5m) transects. Codes prefixed with - indicate transects worked by both authors; those with no prefix indicate transects worked only by the second author.

	shallow					deeper				
island name	code	cov%	cor%	nsp	ncol	code	cov%	cor%	nsp	ncol
Nyamuk besar	-1110	11	0	0	0	-1111	10	2	5	6
Bidadari	-1210	1	1	1	1	-1211	6	2	4	5
Kelor	-1220	1	1	2	2	-1221	8	2	4	5
Onrus	-1310	0	0	1	1	-1311	12	4	7	16
Nyamuk kecil	-2110	2	0	0	0	-2111	13	4	6	7
Air besar	-2210	6	5	8	11	-2211	10	6	14	21
Air kecil	-2220	8	5	12	20	-2221	1	1	1	2
Ubi besar	-2310	0	0	1	1	-2311	1	1	2	3
Utung Jawa	-2320	11	9	8	14	-2321	6	3	5	7
Rambut	-2330	27	15	15	28	-2331	22	5	8	10
Damar kecil	-3110	9	6	8	11	-3111	22	8	12	25
Damar besar	-3120	4	4	5	6	-3121	18	17	20	26
Dapur	-3210	6	1	4	5	-3211	45	34	12	36
Bokor	-3310	14	14	12	18	-3311	30	11	8	26
	3310	14	14	7	12	3311	25	13	8	15
Lancang	3320	25	25	14	31	-3321	33	31	12	71
Tikus	4310	20	20	15	25	-4311	44	24	25	48
Tidung	4320	22	22	16	36	-4321	22	20	23	36
Ayer	4330	17	16	14	17	-4331	26	16	17	28
Kotok besar	-4340	42	40	19	74	4341	39	38	14	31
Kotok kecil	-4350	20	10	16	30	4351	20	12	12	16
Kelapa	5310	25	21	15	20	5311	29	24	13	26
Panjang	5320	16	16	11	34	5321	35	28	10	25
Putri	5330	29	27	18	45	5331	32	32	17	37
Belanda	5340	32	30	15	34	5341	50	48	15	40
Jukung	5350	40	40	9	30	5351	44	42	14	36
Sepak	5360	19	19	9	20	5361	22	18	14	23
Hantu besar	5370	25	24	13	22	5371	18	17	12	25
Hantu kecil	5380	8	7	8	12	5381	23	20	11	23

With one glance at Table IX.2 it becomes clear that the further the reef from Java the higher the listed variables become. An analysis on the correlation between the columns in Table IX.2 (with each of the code-digits also as a separate column) revealed the following significant correlations:

- some correlations exist between the code-digits; these are solely due to the fact that the islands furthest off-shore are only found in the westernmost strip and that there are more islands per sector in these distant regions;

- the first digit (distance to the coast) is highly significantly correlated to the transect averages (total cover, coral cover, number of species, and number of colonies);

- the depth of the transects (fourth digit) is only correlated to total cover and not to the other transect averages;

- the transect averages themselves are all highly significantly intercorrelated.

The first principal component in the reciprocal averaging analysis (ANACOR; see Moll 1983) revealed an arrangement of the transect sites according to their distance off-shore (Figure 9.2). In Figure 9.2 the scores for the first principal component (y-axis) are plotted against the 3-replicate-averages as listed in Table IX.2 (1110=1; 1111=2; 1210=3; etc.).

Previous to the field work period there had been extensive disturbances due to dredging, especially in zones 1 and 2. These activities had a notable impact on nearby islands. In the vicinity of Air Kecil (Code 222) so much sand had been taken away that the island mass was rapidly diminishing and newly dislodged trees and shrubs were found on the shore line. This supposedly explains the poor results for this island when compared to islands from the same sector. Rambut (Code 233) also showed evidence of excessive sedimentation, mostly in deeper water. The effects of these local phenomena are therefore better combined in zone averages than presented as individual values. Examining the average results for each zone, a very clear trend becomes apparent (see Table IX.3).

Table IX.3. Average values of measured parameters for zones 1-5 shown in Figure 9.1. (cov = cover; cor = living coral cover; n. sp. = number of species; n. col. = number of colonies, acs (cm) = average size in cm).

	% cov	% cor	n sp	n col	acs cm
zone 1	061	015	030	045	10.0
2	088	045	067	103	13.2
3	196	148	102	235	18.9
4	272	218	171	341	19.2
5	279	259	128	283	27.6

The values of total cover, coral cover and average-colony size (acs) in particular demonstrate a gradual increase away from the shore. Total living cover is a variable that forces itself upon the observer requiring little interpretation or conventions. Identifying species and distinguishing separate colonies is more subjective to the scientist involved. As one of the authors furnished data for the zones 4 and 5, whereas the other recorded in zone 1 to 4 only, the trend recognised in the cover values, though apparent, is not as straight forward in the data on number of species and number of colonies. There are some difficulties with the interpretation of the colony size. Usually tissue contact is the criterion used (even in coralla with live tissue separated by dead parts), but in for instance large stands of branching

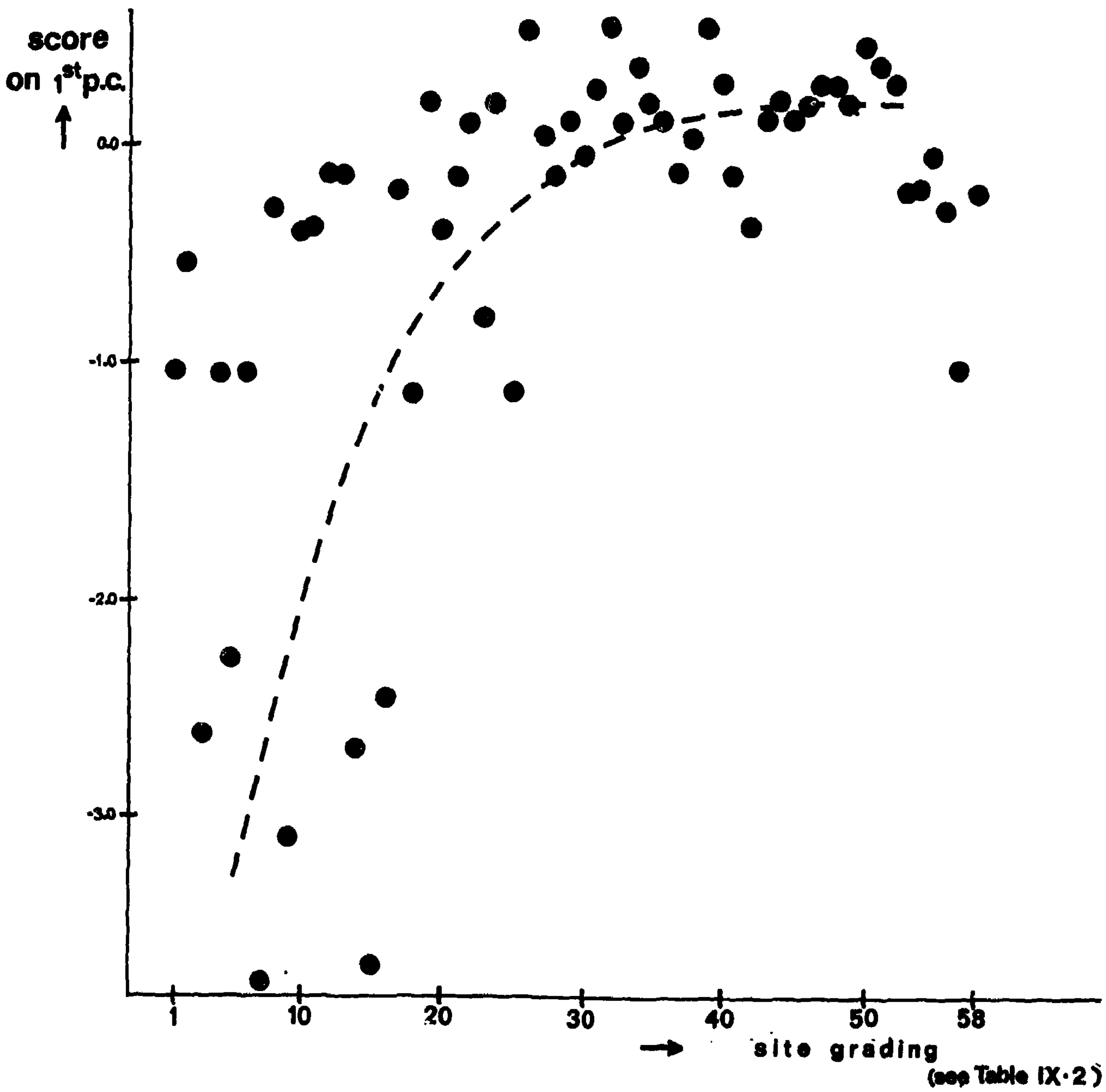


FIGURE 9.2 SCORES FOR THE PRINCIPAL COMPONENT (1st p.c.) IN THE RECIPROCAL AVERAGING ANALYSIS PLOTTED AGAINST THE SITE GRADINGS REFLECTED IN TABLE IX.2 WHERE AVERAGE VALUES OF % COVER, % LIVE CORAL COVER, NUMBER OF SPECIES AND NUMBER OF COLONIES ARE RECORDED FOR 3 REPLICATE TRANSECTS AT SHALLOW AND DEEP WATER LOCATIONS FOR EACH SITE

i.e. Nyamuk Besar shallow site = grading 1
Hantu Kecil deep site = grading 58

Acropora or foliaceous Montipora it can be very difficult to distinguish separate colonies. In such cases, often only the size of the patch was recorded and this complicates the computation of colony number and average colony size.

The average colony size does not differ very much between the shallow sites and the deeper ones (21.3cm per colony). However, examining the five zones (see Figure 9.1) it appears that colonies are larger further away from Java (see Tables IX.3 and IX.4). One possible explanation is that coral life near Jakarta Bay is overcoming even more deleterious conditions in the recent past. As such, these communities could be considered to be in a regenerative stage and thus colonies are younger (smaller) in this area. However, the number of colonies on these reefs is not higher (in fact even much lower) than at the northern most islands, this in contrast to the idea of younger communities with high recent recruitment. More likely reasons for this trend in average colony size are the adverse conditions near the coast. Extreme sedimentation as was observed on these reefs, is certain to hamper regular coral growth and selectively affects the larger colonies (see Moll 1983).

Especially in combination with low water movement conditions, the impact of sediment may be quite ruinous to certain coral species. Where currents or surf affect the area, as near the islands Rambut (Code 233) and Untung Jawa (Code 232), the smothering effect of sediment is greatly diminished in the

Table IX.4. Average values of measured parameters on a number of transects (n tr) within zones 1-5 in shallow and deep locations.

zone	n tr	% cov	% cor	n sp	n col	cm acs
			shallow transects			
1	4x	030	005	010	010	15.0
2	6x	090	057	073	123	13.8
3	6x	120	107	083	137	23.4
4	5x	242	216	160	354	18.3
5	8x	243	230	123	271	25.5
	29x	156	135	095	191	21.3
			deeper transects			
1	4x	090	025	050	080	09.3
2	6x	088	033	060	083	12.0
3	6x	288	190	120	332	17.1
4	5x	252	183	152	265	20.7
5	8x	316	286	133	294	29.1
	29x	221	160	107	224	21.3
Totals	58x	195	151	102	216	21.3

shallower sites. There, coral cover was found to be much higher than at the deeper site where water movement became less.

To compute the diversity and evenness indices the three replicates were combined. As data for these indices (H', J' and D') three sets of data may be used: living cover per species; number of colonies per species; and living cover per colony. The first two of these are independent of the transect length as long as this is larger than the "minimum length" (see Loya and Slobodkin 1971; Loya 1972; Moll 1983) and thus allow for comparisons with other results. The third, however, is not independent and the values it will furnish can only be discussed in reference to areas also sampled by a 30m transect with three replicates. Being less useful this last set of indices was not computed leaving H'c, J'c, D'n, H'n, J'n and D'n.

Average values of the indices are given for zone 1 to 5 (Table IX.5). As mentioned above some differences in recording technique existed so values for zone 4 are split up to be linked with the three previous zones (') or with zone 5(").

Table IX.5. Average values for diversity and evenness indices across zones 1-5. Two values (4' and 4") are given for zone 4 where authors worked independently. Only the second author worked in zone 5".

zone	cov	nsp	H'c	J'c	D'c	H'n	J'n	D'n
1	132	13	212	848	685	231	924	721
2	379	30	293	826	777	317	912	824
3	1128	61	338	794	859	365	859	881
4'	2164	140	405	755	887	454	849	916
4"	2052	85	407	849	912	428	894	930
5"	2286	82	354	772	859	391	852	896

Both H' and D' are heterogeneity indices (see Moll 1983) and follow the same pattern whether cover (c) or number of colonies (n) is used as data. J' is an evenness index and a good indicator of dominance. From zone 1 to 4, it seems that as number of species and coral cover increase, so does diversity. Evenness however, decreases gradually indicating a steady increase of dominance. So even though dominance is becoming more evident further off-shore, the increase in number of species still results in higher diversity values.

In zone 5 dominance has become so pronounced that although cover is higher, number of species is lower than in zone 4. Diversity indices have likewise diminished being sensitive to the number of species in the transect. The increase of dominance from zone 4 to 5 can also be read from the Grime curves for these two areas (Figure 9.3). In biotopes with little dominance and no competition for space the relationship between ln.(cover) and ln.(n.sp) is a linear one (see Moll 1983). In Figure 9.3 the curve for zone 5 levels off sooner, showing that a larger percentage of the substrate is taken up by species with a large cover, i.e. an increase of dominance.

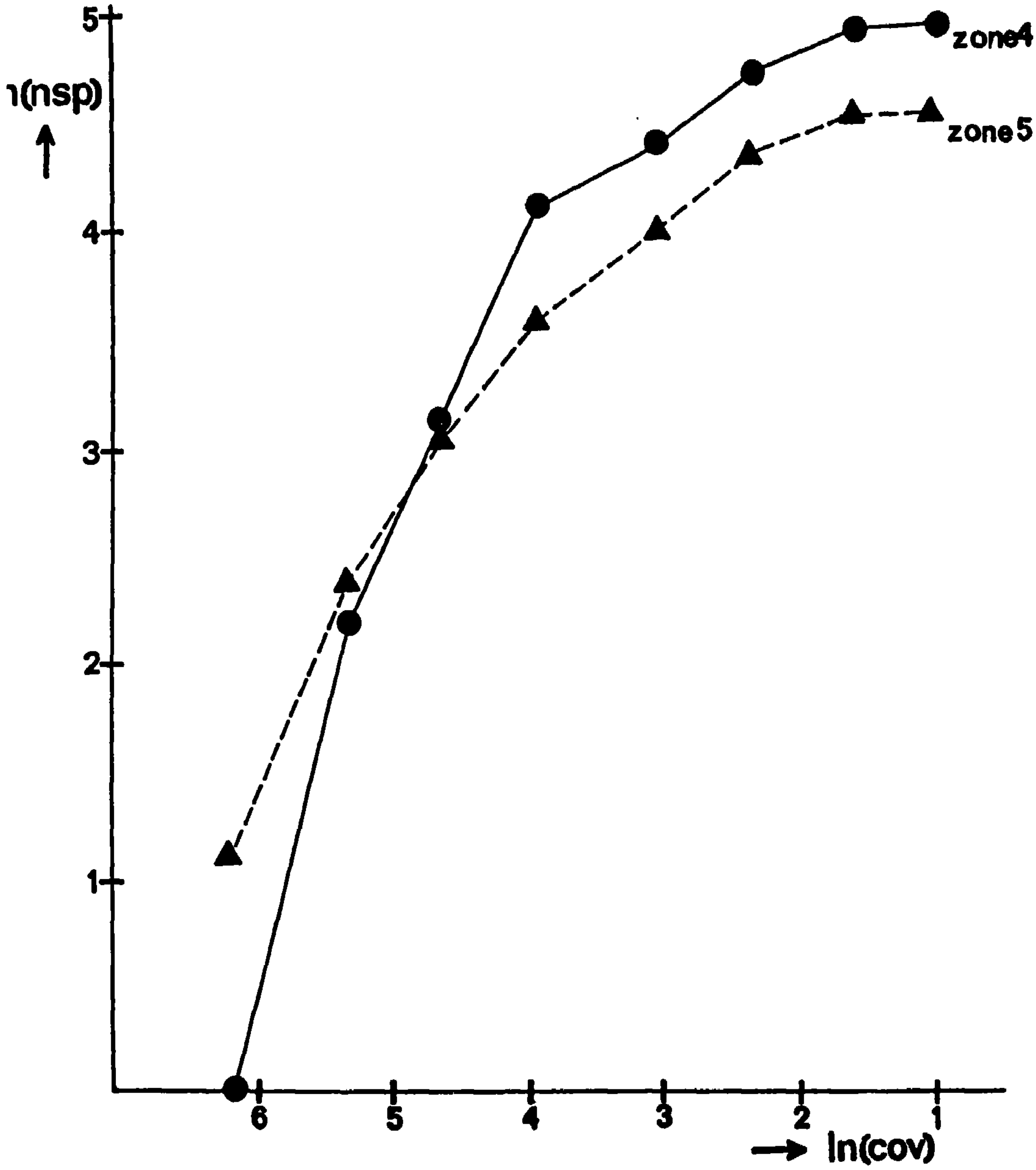


FIGURE 9.3 GRIME CURVES FOR ZONES 4 AND 5 SHOWING FUNCTIONS FOR NUMBER OF SPECIES (In (nsp)) PLOTTED AGAINST FUNCTIONS FOR COVER (In cov))

Discussion

There are several species listed by Umbgrove (1939) that were not recorded in the present survey: Alveopora verrilliana, Alveopora fruticosa ("G. arbuscula"), Goniopora tenuidens, Montipora spumosa, ?Oulangia pallida ("Phyllangia pallida"), Psammocora folium, Psammocora haimeana and Simplastrea vesicularis. Favites flexuosa is reported from the area in a study on the bleaching of corals (Suharsono and Kiswara 1984). Simplastrea vesicularis is of doubtful taxonomy (Wells 1954) as only one damaged specimen has ever been described. All of the others, except Alveopora viridis have been found in the Sankarang Archipelago (Moll 1983) while Favia speciosa and Favites flexuosa are also reported from Eastern Indonesia (Anonymous 1980, Moll 1985).

Verstappen (1953) showed that the bottom deposits for the islands in zone 1 (Figure 9.1) were all of the same order of sand content. He also stated that during the west monsoon sediment expulsion by the north-western arm of the Citarum (as well as the Cikarang) affects all four islands in the same way as far as water transparency is concerned. This would indicate that the sediment is not a parameter affecting the coral composition in this zone. However, during the east monsoon, when westward currents prevail but relatively little sediment is transported, transparency is linearly related to the distance off-shore; deposition of sediment from the K. Angke is likewise related. Therefore, it seems there is still a sedimentation gradient in zone 1, though only during part of the year, which is likely to influence on the coral composition. More recent reports demonstrate that the concentration of various sea water components have a similar distribution (Nontji 1978) although bacterial composition does not (Thayib et al. 1977; Thayib and Listiawati 1978). Whatever happens to the bacteriological input into Jakarta Bay is not clear. It is certain that the bacterial content in the Thousand Islands is comparatively low (Ruyitno and Thayib 1984).

The results of the analyses described above demonstrate that within the area of research, a certain physical or ecological parameter (or group of parameters) has an impact on the reef coral composition that is related to the distance of these reefs from the coast of Java. It is very likely that this impact may be associated with human activity in the area (see also Ongkosongo 1985), whether in the direct vicinity of the reefs, or on Java itself. Effects near the reef themselves (Umbgrove 1928, 1929), such as fishing, coral mining (see Hardenberg 1939; Verstappen 1953), dredging, yatching, building, etc., all have a scewed function with their maximum near Jakarta Bay. The same type of distribution is known for impacts originating from the mainland (pollution from sewage, sedimentation from land erosion, etc.). The extreme sedimentation as observed during field work is not solely due to the effluent of Java but was clearly enhanced by recent dredging for sand. Even if this has been only a temporary event and also if sedimentation from mainland erosion does not increase, the continuing destruction of the adjacent mangrove forests (Soemodihardjo et al. 1977) will result in an increasing sediment load of the water as less and less particles are trapped inshore.

With the population of Indonesia (and especially Java) rapidly increasing it can only be expected that the effect of human activity will intensify in these already affected areas and spread to even the most remote parts of the Thousand Islands. Even now, the "best" diving and camping sites, with yacht clubs and air strips are located near the outermost islands. Unless the marine park management plan for this area (Polunin 1983) is effected very soon, the outcome for Jakarta Bay and even the Thousand Islands will only be a barren warning sign for other less unfortunate regions.

Acknowledgements

(First author)

Thanks are due to Dr J.R.E. Harger (UNESCO, Jakarta) and Dr J.v.d. Land (RMNH, Leiden) for arranging my participation in the workshop. Dr M. Borel Best kindly proof read the article and made valuable suggestions.

(Second author)

I am indebted to the Treub Maatschappij, The Netherlands, for covering expenses for travel and accommodation. Other financial support was thankfully obtained through a grant from the Dutch Ministry for Science and Education.

References

Anonymous (1980). Laporan ekspedisi Rumphius III. (Report on the Rumphius III Expedition). Oceanolgi Indon. 13, 1-60.

Brown, B.E., M.C. Holley, L. Sya'rani and M. Le Tissier (1983). Coral assemblages of reef flats around Pulau Pari, Thousand Islands, Indonesia. Atoll Res. Bull. 281, 1-14.

Hardenberg, J.D.F. (1939). De koraaleilanden in de Baai van Batavia. Verslag Ned. Indische Ver. Natuurbesch. 11, 234-242.

Harger, J.R.E. and Sukarno (1985). Preliminary account of coral reef structure and coral populations in the inner islands of the Pulau Seribu chain. UNESCO, Jakarta, 1-10.

Hutagalung, H.P. and H. Razak (1982). Pengamatan pendahuluan kadar Pd dan Cd dalam air dan biota di estuaria Muara Angke. (Preliminary investigations of Pb and Cd content in water and marine organisms in the Angke estuary). Oceanologi Indon. 15, 1-10.

Kastoro (1982). Sebaran salinitas di perairan estuaria Sungai Karang. (Salinity distribution of the estuarine water of Karang River). Oceanologi Indon. 15, 11-26.

Loya, Y. and L. Slobodkin (1971). The coral reefs of Eilat (Gulf of Eilat, Red Sea). Symp. Zool. Soc. Lond. 28, 117-140.

Loya, Y. (1972). Community structure and species diversity of hermatypic corals at Eilat, Red Sea. Mar. Biol. 13 (2), 100-123.

Moll, H. (1983). Zonation and diversity of reefs off S W. Sulawesi, Indonesia. Thesis Univ. Leiden, 1-102.

Moll, H. (1985). the coral community structure on the reefs visited during the Snellius II Expedition in Eastern Indonesia. Zool. Meded. 1985 (in press).

Nontji, A. (1978). Variasi musiman beberapa factor ecologi di perairan Teluk Jakarta. (Seasonal variation of some ecological factors of the Jakarta Bay). Oceanologi Indon. 11, 27-36.

Ongkosongo, O.S.R. (1985). Evaluation of the ancient and present conditions of the Seribu coral reefs in the Jakarta Bay and the Surroundings. LON (LIPI), Jakarta, 1-33.

Polunin, N.V.C. (1983). The marine resources of Indonesia. Oceanogr. Mar. Biol. Ann. Rev. 21, 455-531.

Ruyitno and S.S. Thayid (1984). Kandungan bakteri di perairan gugus Pulau Pari, Pulau-Pulau Seribu. (Concentrations of bacteria in the waters of Pulau Pari group, Thousand Islands). Oceanologi Indon. 17, 25-32.

Suharsono and W. Kiswara (1984). Kematian alami karang di Laut Jawa. (Natural death of corals in Java Sea). Oceana 9(1), 31-40.

Sukarno (1977a). Penelitian pendahuluan tentang kepadatan karang-batu di terumbu karang Pulau Air, Pulau-Pulau Seribu. (Preliminary study on the diversity and some environmental factors of stony corals on the reefs of Pulau Air, Thousand Islands). Oceanologi Indon. 8, 33-43.

Sukarno (1977b). Fauna karang-batu di terumbu karang Pulau Air dengan catatan tetang ecologisnya. In Hutomo, Romimotarto & Burhanuddin (eds): Teluk Jakarta. Sumber Daya, Sifat-Sifat Oceanologis, serta Pemasalahannya. LON-LIPI, 433-449.

Sumodihardjo, S., K. Kartawinata and S. Prawiroatmodjo (1977). Kondisi hutan payau di Teuk Jakarta dan pulau-pulau sekitarnya. (The condition of mangrove swamps in Jakarta Bay and adjacent islands). Oceanologi Indon. 7, 1-23.

Thayib, S.S., W. Martoyudo and F. Suhadi (1977). Bberapa macam bakteri penyebab penyakit perut manusia pada kerang Anadara dan Crossostera. (Some enteropathogenic bacteria in clams (Andara) and oysters (Crassostera). Oceanologi Indon. 7, 49-55.

Thayib, S.S. and J.T.D. Listiawati (1978). Kondisi bakteriologis perairan Teluk Jakarta. (Bacteriological conditions of the waters of Jakarta Bay). Oceanologi Indon. 10, 15-23.

Umbgrove, J.H.F. (1928). De koraalriffen in de Baai van Batavia. Dienst Mijnb. Ned. Indie, Wetensch. Meded. 7, 1-69.

Umbgrove, J.H.F. (1929). De koraalriffen der Duizend Eilanden. Dienst Mijnb. Ned. Indie, Wetensch. Meded. 12, 1-47.

Umbgrove, J.H.F. (1939). Madreporaria from the Bay of Batavia. Zool. Meded. Leiden 22, 1-64.

Verstappen, H.T. (1953). Djakarta Bay, a geomorphological study on shoreline development. Thesis Univ. Utrecht, 1-101.

Verwey, J. (1931). Coral reef studies. Treubia 13, 169-198.

Wells, J.W. (1954). Scleractinia. In R.C. Moore. Treatise on invertebrate paleontology. Coelenterata. Univ. Kansas Press, F, 328-440.

CHAPTER TEN

BANDING IN CORAL SKELETONS FROM PULAU SERIBU AS REVEALED BY X-RAYS AND U/V LIGHT ANALYSES

T P Scoffin
Grant Institute of Geology
University of Edinburgh
Edinburgh, Scotland
United Kingdom

Purpose of study and methods

In an attempt to test the theory that there is a significant environmental gradient from Jakarta Bay (near shore) to the north of Pulau Kepulauan Seribu (off shore) which influenced coral growth, shallow water massive corals were collected along this transect for banding analyses. The coral species selected was Porites lutea, because this coral was the most abundant on the reef flats, was easily identified, occurred in fist-to-football size colonies that were easy to collect, and was known to show density banding. Three specimens were collected from the reef flats of each island-reef visited (total 28 reefs). Most collections were made in water between 1 and 2 m deep on the reef flat on the northern side of islands. The corals were air dried and cut longitudinally by hand saw into slabs between 5 and 15 mm thick parallel to the growth axes. In the laboratory the coral slabs were cleaned, bleached and treated in an ultrasonic resonator to remove any fine loose particles attached to the skeleton. The corals were photographed on an X-ray machine and quantitative analyses made on the negatives. The same slabs were used for analysis under u/v light.

The physical environment was surveyed at open water locations close to the coral collection sites. The parameters measured were water temperature, salinity (both at the surface and 3m depth) and water clarity which was estimated using the depth of extinction of a secchi disc. The reef flat or edge was visually surveyed by snorkeling at the time of coral collections. An estimate was made of the percentage coral cover and a brief list of the dominant corals made noting the relative degree of active bioerosion (especially by Diadema, Lithophaga, boring worms and sponges).

Results

a) Reefs

All the reefs visited were surrounding vegetated islands. The reef and island sizes varied within the chain, but, in general, the islands were between 300 and 1000 m in diameter and the reef flats between 50 and 200 m wide.

b) Rainfall data

We do not have meteorological data for the Pulau Seribu. The data available all comes from stations on the mainland of Java. The figures at sea level for Tanjung Priok (near Jakarta) are the ones quoted here in table X.1. These records are incomplete but give a good idea of the seasonal variation in climate.

c) Water quality

The water quality data are presented in Table X.2. There was not a consistent trend in temperature or salinity between 0 and 3m depth, though surface waters were commonly less saline after heavy rain. Consistent low salinity waters occur close to the mainland. Higher salinities were recorded to the east and to the north and correlate with higher percentages of coral cover. Salinity values levelled off around 32°/.. to the north of Pulau Pari. Water temperatures ranged from 26°C to 30°C, with the highest values being in the Bidadari region of Jakarta Bay. Secchi disc measurements showed that the clearer waters were normally on the north (windward) sides of the islands. The southern sides of islands were commonly the more densely populated, thus urban effluence was greater on this leeward side of the island-reef systems. The confluence of refracted waves on the leeward sides of islands further contributed to the relative cloudiness of the water on the southern margin of the reef flats. Secchi disc values were as low as 2.5 m on reefs near to Bidadari in Jakarta Bay but visibility increased to the north along the island chain. Highest values were in the Pari region (up to 28 m). Examination of satellite imagery (June 1976) reveals distinctive zones of sediment laden water in this immediately post-wet monsoon period. One such body of water lies close to shore and encompasses reefs in a radius of about 5 km (i.e. as far as Ubi Besar and Utung Jawa). In the outermost stretches of the island chain there is a very widespread (c. 20 km diameter) zone of sediment-rich water which stretches from the northern limit of the chain south as far as Congkak (Jongkak). The intermediate zone has the clearest water judging from the satellite image though elongate ribbons of cloudy water are strung E-W in this zone suggesting swift east to west currents paralleling the north coast of Java in the region of Pulau Pari.

d) Skeletal banding

i) X-radiography. Clear banding was not seen in those corals that had suffered extensive infestation by boring organisms. This was the case for most samples in the Bidadari (near-shore) region. All other samples showed density banding. A summary of the results are shown in Table X.3. This Table records the average thickness in mm of the three pre-1985 years, encompassed between high density bands (assuming density couplets to be annual). Examination of the corals (and Table X.3) shows a wide range of variation in thickness of density banding. The variation occurs between reefs, between corals on one reef and between bands (years) in one coral. In general the linear extension is of the order of 10 mm per year. If the reefs are segregated into three areas we note the average annual extension for the inner zone (Jakarta Bay) reefs is 7.5 mm, for the middle zone (Pulau Pari) reefs is 11.7 mm and for the outer zone (Pulau Putri) reefs is 9.8 mm. It could be that some high density bands were not recognised so that those very high values for linear growth (e.g. East Lancang) may represent two years' growth increment and not one. Generally the low density bands were the wider of each couplet. Also, the vast majority of corals showed that the most recent band excreted was of low density growth. This LD band immediately preceding the time of collection (May 1985) averaged 7mm in thickness. Though we have no internal dated marker for any of the corals, this recent low density band does suggest that the preceding few months (correlating with the wet season) was a time of optimum growth.

ii) u/v banding

Though most corals clearly show a banding under u/v light, the nature of the banding is not easy to quantify with the instrumentation available. The banding in general is defined by thin bright yellowish bands superimposed on a broader white to bluish background. Table X.4 gives a summary of some representative u/v banding patterns. The thickness of bright and dull bands were measured and a dull : bright index determined for each coral. The following points emerge from an analysis of the bands:

1) Organism infestation destroys banding.

2) Those corals from the inner zone reefs (Jakarta Bay) have broad bright bands and the skeletons fluoresce fairly brightly throughout making band distinction difficult.

3) Clearest banding is seen in corals from the middle and outer zone reefs. Here the bright yellow bands are thin against a relatively dark (compared with inner zone reefs) broad background band.

4) The dull : bright index increases along the chain away from the mainland from low values of the order of 1 inshore to high values over 3 well away from the coast.

5) Double bright bands (normally with a sharp start and end) are common and may correlate between corals on one reef flat but do not seem to correlate between reefs at all.

6) Banding patterns overall do not correlate well between reefs, though most corals show the most recent growth (3 to 6 mm) to be in a dull band subsequent to a very narrow (1-2 mm) bright band.

7) In some instances, corals collected from one reef have similar u/v banding patterns (e.g. Damar Besar) but in others the banding patterns are quite dissimilar (e.g. Air Besar)

8) The u/v banding patterns can not be meaningfully correlated with the rainfall data from Jakarta area (Table X.1).

9) The u/v banding patterns for individual corals do not match well with the density banding as revealed by X-rays. In general though bright u/v bands correlate with low density bands.

10) The u/v banding appears to be of a more regular pattern than the density banding for the same coral, though overall the average thickness of bright + dull couplets is 9.4 mm which is not dissimilar to the thickness for density couplets and suggests each bright + dull couplet represents one year's growth.

11) The orientation of u/v bands within corals, especially on the broken surfaces of slabs, does show that the slabs were not always cut perfectly parallel to the axial direction. In particular, in this study, many of the X-rays density patterns have been confused by the overlapping of several adjacent bands. This shows that it is

important to subject the corals to u/v analysis (in two dimensions) prior to X-radiography and where necessary cut thinner slabs for X-ray work.

Discussion

If bright u/v bands relate to fulvic acids in fresh water run off from land then it appears that this supply is not from one source at one time each year. Several possibilities exist: 1) a single period of flood input from the Java mainland may be broken into discrete water bodies that cross the area with varying residence times depending on winds and currents. 2) Each reef island provides its own fulvic acid source for the nearby corals. Run off from one island may affect the reefs of neighbouring islands. The fresh water run off from individual islands may be radially symmetrical, it may be predominantly to leeward, or its course may relate to permeability pathways in the subsurface.

The second possibility (i.e. local island sources) is favoured here as there is no consistent relationship between u/v banding and mainland rainfall data; though it is clear from the wider, brighter and more diffuse bands in the inner reef zone of Jakarta Bay that there is a swamping of any local signal by a persistent fresh water influx which is clearly from the mainland (supported by salinity data).

We do not have sufficient data to explain the density banding patterns or their relationships with u/v banding. It does appear that the density banding is more complex than can be caused by stress related to rainfall alone.

Table X.1

Meteorological data for Jakarta

	Rainfall	Mean Air T°	Mean % Sunshine (per 8h)	% Cloudiness
Feb. 1985	174	27.0	43	70
Jan. "	396	26.3	42	69
Dec. 1984	-	-	-	-
Nov. "	116	27.1	47	65
Oct. "	73	27.4	50	67
Sept. "	107	26.3	48	67
Aug. "	83	27.1	77	59
July "	40	26.9	62	59
June "	-	-	-	-
May "	210	26.9	57	66
April "	95	27.2	54	68
March "	304	26.3	49	68
Feb. "	292	26.0	32	72
Jan. "	294	26.4	23	73
Dec. 1983	-	-	-	-
Nov. "	137	27.4	35	68
Oct. "	192	27.6	66	63
Sept. "	0?	28.2	85	57
Aug. "	-	-	-	-
July "	27	27.5	84	73
June "	0	28.5	84	74
May "	-	-	-	-
April "	113	28.6	59	76
March "	151	28.1	81	79
Feb "	106	27.6	55.6	81
Jan "	48.5	27.6	24.5	82

	Rainfall (only)
Dec. 1982	-
Nov. "	9
Oct "	3
Sept. "	0
Aug. "	30
July "	1
June "	83
May "	15
April "	31
March "	193
Feb. "	292
Jan. "	374
Dec. 1981	-
Nov. "	-
Oct. "	-
Sept. "	-
Aug. "	49
July "	115
June "	42
May "	83
April "	189
March "	101
Feb. "	185
Jan. "	451

Table X.2

Field Data

ISLAND	DATE	TIME	TEMP °C 0m	3m	SALINITY % 0m	3m	SECCHI DISC	% CORAL COVER	CORALS (in order of abundance)	COMMENTS
Kayangan	7 May 85	11.50	29.1	29.2	30.2	30.1	8	1%	Faviids Porites	Diadema abundant worms, sponges
Kayangan	7 May 85	11.55	30.0	30.0	29.4	29.5	8.7	1%	Porites Faviids	Diadema abundant worms, sponges
Onrust	7 May 85	12.45	28.9	30.0	29.9	30.0	3	1%	Porites Faviids	Diadema abundant worms, sponges
Bidadari	7 May 85	14.33	29.5	28.1	29.9	31.0	3	1%	Porites, Acropora, Stylopora	Diadema abundant worms, sponges
Kelor	8 May 85	07.50	29.8	33.5	27.4	28.1	3.7	1%	Acropora, Faviids, Porites, Montipora	Diadema common
Air Besar	8 May 85	04.32	26.2	30.1	32.5	30.5	9	20%	Porites, Goniastrea, Heliopora, Acropora	Diadema rare worms, sponges
Ubi Besar	8 May 85	11.50	26.6	31.1	31.4	29.6	4	1%	Goniastrea, Montipora, Porites	Diadema abundant worms, sponges
Damar Besar	9 May 85	8.50	25.4	26.1	33.2	33.2	9	40%	Acropora, Porites, Montipor Faviids	
Damar Kecil	9 May 85	11.50	26.0	25.9	33.2	33.2	12	25%	Porites faviids, Acropora, Heliopora	Diadema
Nyamuk Besar	9 May 85	12.57	26.1	26.0	33.5	33.6	8	1%	Acropora Porites Goniopora	Diadema abundant worms, sponges
Nyamuk Kecil	9 May 85	13.58	28.2	28.1	3.19	31.9	9	15%	Porites, Acropora, Faviids, Pavona	Diadema
Air Kecil	10 May 85	8.20	28.50	28.5	31.0	31.0	9	5%	Acropora, Faviids, Porites	worms, sponges
Dapur	10 May 85	09.26	28.2	28.2	32.1	32.0	11	25%	Acropora, Pocillopora Porites, Montipora	
Bokor	10 May 85	11.22	29.0	28.8	31.6	31.7	5	20%	Porites, Acropora Faviids, Fungiids	worms, sponges
Untung Jawa	11 May 85	8.28	28.9	28.8	29.6	28.6	6	30%	Acropora, Faviids Heliopora, Montipora	worms, sponges
Rambut	11 May 85	11.00	28.4	29.1	29.1	28.5	2.5	15%	Faviids, Porites, Acropora	
East Lancang	13 May 85	9.30	26.9	27.5	30.8	30.5	7.5	10%	Montipora, Pocillopora Faviids, Acropora	
West Lancang	13 May 85	12.44	27.2	27.0	32.0	33.1	7	25%	Montipora, Acropora, Porites	
Congkak (Jongkak)	14 May 85	10.14	27.5	27.5	30.0	31.5	21	5%	Porites, Pocillopora, Montipora	
Simpit	14 May 85	12.30	27.4	27.8	30.7	32.4	28			
Ayer	14 May 85	13.00	26.7	26.9	33.6	32.5	24	45%	Acropora, Montipora, Porites Seriatopora	
N. Pari	14 May 85	16.00	27.8	27.2	31.8	33.5	13			
Tikus	14 May 85	08.35	26.7	26.9	32.9	31.9	11			
Payong	15 May 85	09.10	27.1	26.9	29.7	32.5	20	55%	Acropora, Millepora, Montipora	
Hantu Kecil	17 May 85	11.00	29.0	29.0	32.0	32.2	13	15%	Acropora, Montipora, Faviids	
Jukung	17 May 85	12.30	29.0	29.0	32.0	32.0	15	35%	Montipora, Acropora, Millepora, Fungiids	
Sepak	17 May 85						14			
Putri	18 May 85	09.10	29.0	29.0	32.0	32.0	14	30-80%	Montipora, Porites, Acropora, Millepora, Fungiids	
Panjang	18 May 85	11.45	27.1	27.1	33.0	32.9	13	30%	Acropora, Montipora Turbinaria, Millepora	
Kelapa	18 May 85	13.20	28.0	28.0	32.5	32.7	14	22%	Porites, Acropora, Montipora	
Belando	18 May 85						16			

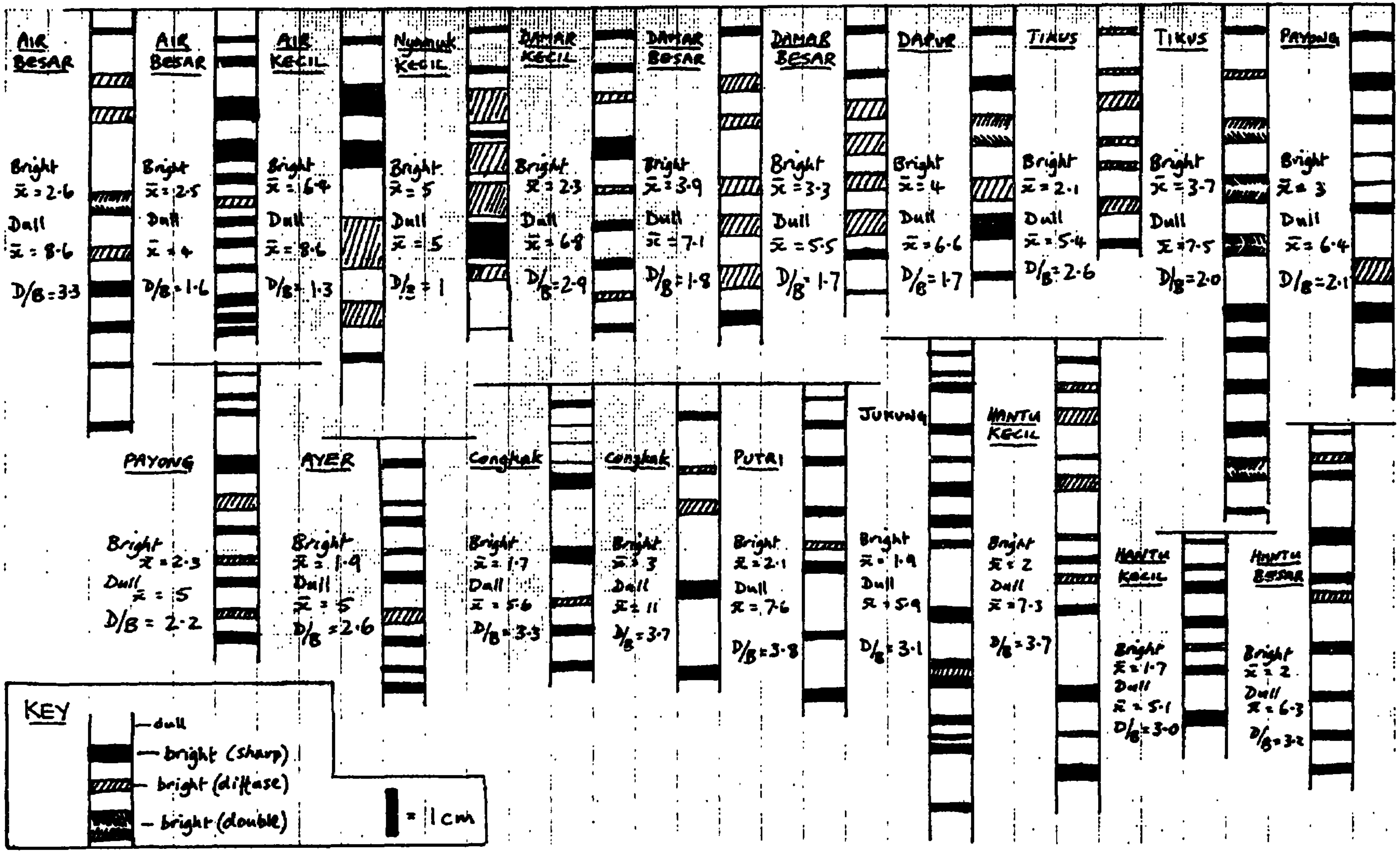
Table X.3

Means of measures of Dense-to-Dense band thickness (in mm) for 1984, 1983, 1982 for each sample ((1), (2), (3)) + overall mean for island, bracketed figure is standard deviation. Last band (1985) is indicated as low density (LD) or high density (HD). The list is arranged alphabetically.

AIR BESAR	(1)	15.2	(1.3)	12.0 (2.3)	LD
	(2)	10.6	(1.4)		
	(3)	11.2	(1.2)		
AIR KECIL	(1)	10.0	(2.4)	8.9 (2.1)	LD
	(2)	7.8	(1.3)		
	(3)	8.5	(1.5)		
AYER	(1)	16.6	(1.6)	12.1 (4.3)	LD
	(2)	10.0	(.6)		
	(3)	5.0	(0)		
BIDADARI	(1)	9.3	(1.9)	9.3 (1.9)	LD
BOKOR	(1)	12.6	(2.1)	12.1 (1.8)	LD
	(2)	13.0	(0)		
	(3)	10.8	(1.4)		
CIPIR	(3)	7.8	(0.3)	7.9 (1.0)	HD
	(4)	8.0	(1.2)		
CONGKAK (JONGKAK)	(1)	9.5	(4.7)	8.3 (3.7)	LD
	(2)	5.7	(0.9)		
	(3)	8.7	(1.2)		
DAMAR BESAR	(1)	10.6	(1.8)	9.3 (2.5)	LD
	(2)	9.0	(0)		
	(3)	5.5	(.5)		
DAPUR	(1)	9.6	(1.4)	8.0 (2.2)	LD
	(2)	6.6	(0.9)		
	(3)	5.0	(0)		
EAST LANCANG	(1)	18.0	(1)	17.0 (1.4)	HD
	(2)	15.5	(1.5)		
	(3)	17.3	(0.5)		
HANTU BESAR		10.0	(1)	10.0 (1)	LD
HANTU KECIL	(1)	9.6	(1.8)	8.9 (2.1)	LD
	(2)	6.5	(5)		
JUKUNG	(1)	7.6	(1.7)	8.2 (1.9)	LD
	(2)	8.6	(1.9)		
KELAPA	(1)	14.3	(2.7)	12.8 (3.2)	LD
	(2)	13.3	(2.5)		
	(3)	9.0	(0.8)		

KELOR	(1)	6.0	(0)	6.0 (0)	
NYAMUK BESAR	(1)	8.0	(1.8)	8.0 (1.8)	HD
NYAMUK KECIL	(1)	10.8	(0.9)	9.7 (2.1)	HD
NORTH PARI	(1)	14.7	(1.4)	10.9 (3.8)	LD
	(2)	9.2	(1.1)		
	(3)	15.0	(0.8)		
	(4)	10.7	(2.2)		
PANJANG	(1)	11.2	(1.9)	13.9 (3.6)	LD
	(2)	14.6	(3.4)		
	(3)	18.0	(0.8)		
PAYONG	(1)	6.6	(1.2)	7.0 (1.2)	LD
	(2)	8.3	(10.5)		
	(3)	6.0	(0)		
PUTRI	(1)	13.0	(1.8)	10.1 (2.9)	LD
	(2)	9.7	(1.5)		
	(3)	6.3	(0.9)		
RAMBUT	(1)	8.3	(2.1)	7.9 (2.0)	LD
	(2)	7.0	(1.4)		
SEPAK	(1)	15.2	(1.1)	15.2 (1.1)	LD
TIKUS	(1)	8.2	(1.7)	9.0 (1.8)	LD
	(2)	10.0	(2.2)		
UBI BESAR	(1)	5.2	(1.1)	5.2 (1.1)	LD
UTUNG JAWA	(1)	7.5	(2.4)	7.5 (2.4)	LD
WEST LANCANG	(1)	12.6	(2.0)	10.5 (3.2)	LD
	(2)	12.6	(3.2)		
	(4)	8.3	(1.9)		

TABLE X·4. Summary of representative U/V banding patterns.



CHAPTER ELEVEN

DISTRIBUTION OF REEF FISH ALONG TRANSECTS IN BAY OF JAKARTA AND KEPULAUAN SERIBU

Malikusworo Hutomo and Muhammad Adrim
National Institute of Oceanology
Indonesian Institute of Sciences, Jakarta

Introduction

Coral reefs of the Kepulauan Seribu and islands in Jakarta Bay are mostly fringing reefs. They surround more than one hundred small islands. The islands, in general, they have narrow shores composed of coarse sand. Their reef flats are wide, and the moats and reef ramparts are located near the reef slope. The coral community of the reef flat and upper reef slope is dominated by *Acropora* and *Montipora*.

A number of studies have been made on the Seribu Island coral reefs, but only one study on the fish community has been attempted (Hutomo and Martosewojo 1977).

The present work studies the species composition and distribution of coral reef fish communities along transects at 22 islands in Bay of Jakarta and Seribu Islands. The diversity and abundance of the fish community in relation to coral reef conditions were also analysed.

Materials and Methods

The survey was carried out from May 7 to 18, 1985. Fish censuses were performed in the following manner. The northern reefs of 22 islands within Jakarta Bay and Seribu Islands were censused (Figure 11.1). At each location, the census was carried out on the flat (1-1.5m deep) and reef slope (3-7m deep) by snorkelling and skin diving. The censused area covered about 4 x 100m (2m either side of a 100m transect line, parallel to the reef rampart). All species of fish in the transect area were recorded but only those belonging to the families Chaetodontidae, Lutjanidae and Lethrinidae were counted.

Results

Altogether, 132 species of fish belonging to 24 families were recorded during a twelve day survey period in Jakarta Bay and the Seribu Islands. One hundred and twenty one and seventy one species were censused on the reef slope and reef edge respectively. More detailed data on the distribution of each fish species on the reef slope and reef flat is given in Appendices 11.1 and 11.2 following this chapter.

Reef edge

Holocentridae. Probably more than one species of holocentrid was

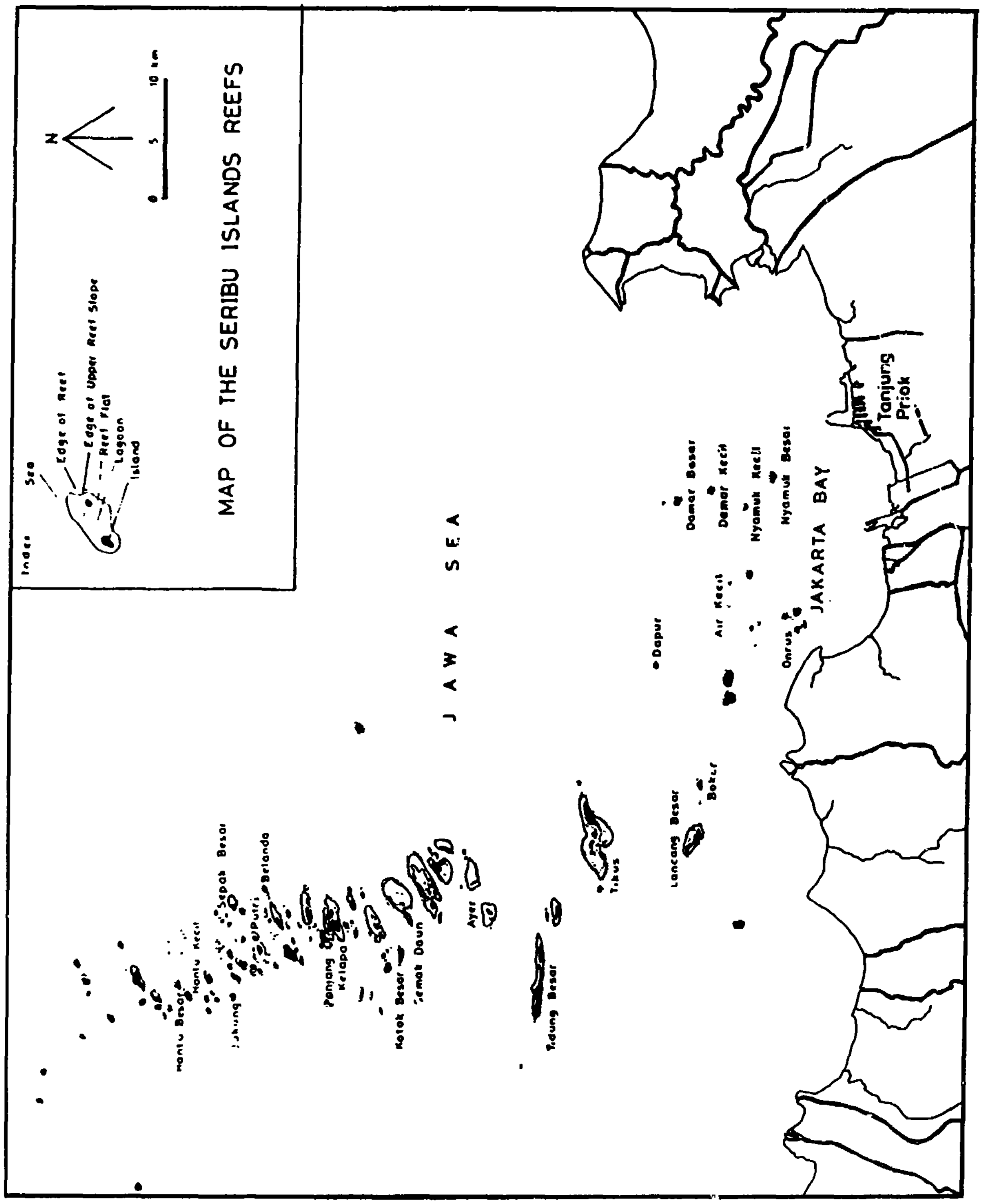


FIGURE 11.1 THE TRANSECTED ISLANDS IN BAY OF JAKARTA AND SERIBU ISLANDS

observed during the survey period. Some species were very rare, only being recorded at P. Kotok Besar, P. Tikus and P. Tidung Besar. Since the fish group is nocturnal, they were rarely recorded during day time when the census was completed.

Centriscidae. Only one species, Aeoliscus strigatus, which was recorded at P. Onrust.

Fistulariidae. Only one species, Fistularia villosa, which was recorded at P. Kotok Besar.

Apogonidae. Four species were recorded with Cheilodipterus quinquelineatus forming the most common species in this family.

Serranidae. This group is one of the economically important reef fishes which are highly demanded by seafood restaurants in Jakarta. Eight species were recorded with Cephalopolis pachycentron forming the most abundant and widely distributed species. However it is small in size and economically less important than other serranids. The second most common species was Cephalopolis miniata. Plectropomus maculatus, the most economically demanded species, was recorded at P. Lacang, P. Semak Daun, P. Jukung and P. Kelapa. The other species, Epinephelus fuscoguttatus, E. megachir, E. summana and Epinephelus sp. were rarely found.

Lutjanidae. This family is also economically important. Four species were recorded, with Lutjanus decussatus the most abundant and widely distributed species. This fish was found in considerable numbers at P. Semak Daun, P. Kelapa and P. Belanda. L. fulviflamma is the second most important species and was abundantly found at P. Kotok Besar and P. Panjang.

Caesiodidae. This family is the most important fish group captured in the coral reef fishery described as the 'muro-ami' fishery which involves the use of a circle net. The fishery is widely practiced by fishermen of the Seribu Islands. Three species were recorded in the survey with Caesio erythrogaster the most widely distributed species.

Nemipteridae. Five species were recorded. Scolopsis margaritifer and S. bilineatus were the most widely distributed species. One species, Pentapodus caninus, was found only at P. Putri.

Haemulidae. Three species were rarely recorded. These species are important edible reef species.

Lethrinidae. This family is another economically important reef fish. Three species were recorded with Lethrinus kallopterus forming the most widely distributed species. Lethrinus sp. (maybe L. lentjan) was found in relatively large numbers at P. Tidung Besar.

Mullidae. Two species were recorded; their distribution being very limited.

Ephippididae. Only one species, Platax orbicularis was found. This species was quite abundant at P. Ayer.

Chaetodontidae. Fourteen species were recorded, Chaetodon octofasciatus forming the most abundant and widely distributed species, which occurred in all the transected islands except three (i.e. P. Nyamuk Besar, P. Nyamuk Kecil and P. Onrust). It was found abundantly at P. Kotok Besar (28 individuals), P. Belanda (17 individuals), P. Ayer and P. Putri (13 individuals) and P. Lancang Besar (10 individuals). Chaetodon triangulum formed the second most common species. C. collare, C. ephippium and Chaetodon sp. were very rare and were only once recorded. The greatest number of Chaetodon species were found at P. Ayer (5 species), with four Chaetodon species being found at P. Bokor, P. Hantu Kecil, P. Putri and P. Belanda.

Pomacanthidae. Six species were recorded during the survey period. Chaetodontoplus mesoleucus formed the most abundant and widely distributed species. This species was found in largest numbers at P. Kotok Besar. Pomacanthus sp. and Pygoplites diacanthus were the rarest species seen and were only once recorded at P.Putri and P. Kotok Besar.

Pomacentridae. This family has the largest species number; 26 species were recorded during the survey period. Paraglyphidodon melas and Amblyglyphidodon curacao were the most widely distributed species; they were recorded in 17 and 15 out of the 22 islands, respectively. Most of the other species were also commonly recorded, except Amphiprion polymnus and Pomacentrus argyreus which were only once recorded at P. Damar Kecil and P. Kotok Besar, respectively.

Labridae. This family contains the second largest number of species with 20 species recorded during the survey period. Thalassoma lunare forms the most common species; Labroides dimidiatus, Hemigymnus melapterus, Halichoeres hortulanus, Epibulus insidiator and Cheilinus fasciatus were also common. In general, other species were fairly common, excepting Halichoeres argus and Choerodon anchorago which were recorded on only one or two islands, respectively.

Scaridae. Thirteen species were recorded during the survey period. Scarus niger formed the most common species, and was recorded in twelve islands. Scarus fasciatus was the second most common species, being recorded in nine islands. Cetoscarus bicolor, Scarus bilineatus, S. sordidus and S. venosus were rare, being only recorded once during the survey period.

Blenniidae. Since its mode of life is as a bottom dweller, individuals of this family were rarely seen in the census. One unidentified species was recorded at P. Onrust only.

Siganidae. Three species were censused during the survey period. Siganus virgatus was the most widely distributed species.

Zanclidae. Only one species, Zanclus canescens, was recorded during the survey period. It was found at P. Lancang Besar, P. Kotok Besar, P. Tidung Besar, P. Hantu Besar and P. Hantu Kecil.

Acanthuridae. Two species were recorded during the survey period, both were rare. Acanthurus lineatus was censused at P. Bokor and P. Belanda; Paracanthurus hepatus was recorded at P. Sepak Besar.

Scorpaenidae. One species, Pterois zebra, was recorded at P. Kotok Besar.

Balistidae. Only one species, Balistapus sp., was recorded at P. Jukung.

Monacanthidae. One species, Alutera scripta, was censused at P. Hantu Besar.

Reef front

Holocentridae. One unidentified holocentrid species was recorded at P. Kotok Besar.

Centriscidae. One species, Aeoliscus strigatus, was recorded at P. Tidung Besar.

Serranidae. Four species were recorded during the survey period. Cephalopolis pachycentron was the most common species. The other three species have a limited distribution.

Lutjanidae. Two species were censused, with Lutjanus decussatus forming the most widely-distributed species.

Nemipteridae. Four species were recorded, with Scolopsis bilineatus having the widest distribution. The other two Scolopsis species, S. cancellatus and S. margaritifer, had relatively wide distribution patterns too. Pentapodus caninus, was recorded at P. Nyamuk Kecil and P. Sepak Besar.

Lethrinidae. Two species, Lethrinus harak and L. kallopterus, were both recorded at P. Tikus.

Mullidae. One species, Upeneus tragula, was recorded at P. Bokor and P. Tidung Besar.

Chaetodontidae. Eight species were recorded during the survey period. Chaetodon octofasciatus formed the most widely distributed species. In general, this species was found in relatively large numbers except at P. Lancang (one individual), and was found in greatest abundance at P. Kotok Besar (twenty five individuals). Chaetodon rafflesii, C. speculum and C. vagabundus were recorded only once during the survey period.

Pomacanthidae. Two species, Centropyge septipinnis and Chaetodontoplus mesoleucus, were recorded during the survey period. Both species were rare.

Pomacentridae. This family was represented by a large number of species with nineteen species being recorded during the survey period. Paraglyphidodon melas and Plectroglyphidodon lacrymatus form the most widely distributed species. In general, other species were commonly recorded, excepting Amphiprion equippium, A. percula, Dascyllus trimaculatus, Dischistodus chrysopoecilus, D. prosopotaenia and Premnas flacicauda which were rare.

Labridae. This family was also well represented in terms of number of species with seventeen species being recorded during the survey period. Thalassoma lunare forms the most widely distributed species. Halichoeres hortulanus and H. hardwickii form the second most widely distributed species. Stethojulis interrupta, S. strigiventer and Thaliurus chlorurus were very rarely recorded.

Scaridae. Six species were recorded during the survey period. Scarus margaritus was the most common species. Other species were rarely recorded.

Siganidae. Three species were recorded during the survey period. In general they were rare.

Zanclidae. Only one species, Zanclus canescens, was infrequently recorded.

Acanthuridae. Two species, Acanthurus lineatus and A. glaucopareius, were recorded.

Discussion

The results of the survey show that fish diversity and abundance are higher on the reef slope than on the reef edge. The above statement is clearly shown by the high number of species and genera of all fishes as well as the higher number of species and greater abundance of chaetodontids on the reef slope when compared with the reef edge (Tables XI.1 and XI.2). In both zones Pomacentridae and Labridae form the dominant families. Tay and Kho (1984) also found that the reef slope of Pulau Salu forms the most densely populated zone on the coral reef of Pulau Salu, Singapore.

Coral reefs have many functions, which include providing a habitat for living organisms, such as fish. As a habitat for fish this ecosystem provides shelter and also forms the feeding, spawning and nursery grounds. Logically, reef fishes are strongly dependent upon the condition of a coral reef which is usually indicated by the percent cover of living coral. Based on this criterion, the surveyed islands can be divided in three zones. Zone 1 consists of islands in Jakarta Bay; zone 2 consists of islands outside Jakarta Bay but which may be affected by the waste of Jakarta city; and zone 3 consists of islands further north which have relatively clear water and may no longer be affected by waste from Jakarta city.

The condition of coral reefs in zone 1 ranges from poor - moderately good. On some reefs the percent cover of living coral is less than 10%, for example P. Ubi Besar (0.33%) and P. Nyamuk Besar (1.33%). The island reef which is still in relatively good condition is P. Damar Besar (22%).

In zone 2, the coral reefs around the island are in moderate condition. the percent cover of living coral generally ranges between 20-30%.

The condition of reefs around islands in zone 3 is more variable, their coral coverage ranging between less than 10% to more than 40%. The best coral reef conditions are found in P. Belanda and P. Jukung where percent living cover is 39.73% and 41.8% respectively. In this zone, however, island reefs with poor coral cover can still be found, for example P. Hantu Kecil (8.5% coral coverage), P. Kelapa (11.53% coral coverage), P. Panjung (13.5% coral coverage). Damages on these island reefs could be caused by explosives (P. Hantu Kecil) and population pressure (P. Kelapa). But, in general, there is a positive correlation between coral reef health which is indicated by percent cover of living coral and distance of island from the mainland (Figure 11.2). In other words, the further the island from land the better is the condition of its reef.

Table XI.1. Number of fish species per family on the reef slopes of transected island reefs in the Bay of Jakarta and Seribu Islands.

Family \ Locations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
1. Holocentridae									1														1
2. Centriscidae									1														1
3. Fistulariidae											1												1
4. Apogonidae				1					2										3				4
5. Serranidae	1		1	1	2	1	1	5		3	2	2	3			1	2	1	2	2	1	2	9
6. Lutjanidae		2	1			1	3	1		2	3	3	1	1	2	1	1	1	1	2	2	1	4
7. Caesiodidae				1	1			1			1	1		2	1	1					1		3
8. Nemipteridae	3	2	3	1	2	2	2	2		2	1	2	2	2	1	1	3	2	2	2	1	2	5
9. Haemulidae		1	1				1						1								1		3
10. Lethrinidae		1								1	1	1		3					1	1	1		3
11. Mullidae							1			1				1									2
12. Ephippididae												1	1					1				1	1
13. Chaetodontidae	1	2	2	1	1	1	4	1		2	1	5	2	2	1	4	3	3	4	1	3	4	13
14. Pomacanthidae			1							1	3	3	2	1	1	1	1		3	1	1	1	6
15. Pomacentridae	3	4	1	2	3	5	6	9	1	7	8	5	7	5	8	12	11	11	10	8	6	11	24
16. Labridae	2	4	3	3	3	3	7	6	1	8	7	5	6	7	6	5	5	4	5	6	4	8	18
17. Scaridae	1	2	2	1		1	4	1		3	5	4	4	3		1	4	5	3	3	1	4	13
18. Blenniidae									1														1
19. Siganidae		1	2				1			1	2	3	2	1	1		1	1	1	2	1	1	3
20. Zanclidae								1				1			1	1	1						1
21. Acanthuridae							1										1					1	2
22. Scorpaenidae												1											1
23. Balistidae																	1						1
24. Monacanthidae															1								1
Total no. of species	11	19	17	11	12	14	31	27	7	31	35	37	31	28	23	28	34	29	35	28	23	36	121
No. of families	6	9	10	8	6	7	11	9	5	11	14	13	12	12	10	10	11	10	12	9	12	11	

Table XI.2. Number of fish species per family on the reef edges of the transected island reefs in the Bay of Jakarta and Seribu Islands.

Family \ Locations	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
1. Holocentridae							1												1
2. Centriscidae										1									1
3. Serranidae	1		1	1		1		1	1	1		1			1		1		4
4. Lutjanidae		1	1			1	1		1					1	2		1		2
5. Nemipteridae			3	2		1	2	2	2	2	2		1	3	1	1	3	1	4
6. Lethrinidae									2										2
7. Mullidae			1							1									1
8. Chaetodontidae			1	2		1	1	1	4	1	1	1	1	3	4	1	1	3	9
9. Pomacanthidae						1	1	1	1							1	1		2
10. Pomacentridae	2	3	6	4		1	9	6	1	6	5	7	5	6	4	8	10	6	17
11. Labridae	1	2	10	6		6	4	5	3	2	3	3	4	5	2	6	5	5	16
12. Scaridae				1		2	3		2	1				1	1			1	6
13. Siganidae			1					1						1	1			1	3
14. Zanclidae							1		1										1
15. Acanthuridae								1	1							1			2
Total no. of species	4	6	24	16		20	23	18	19	15	11	12	11	20	16	18	23	16	71
No. of families	3	3	8	6		8	9	8	11	8	4	4	4	7	8	6	8	5	

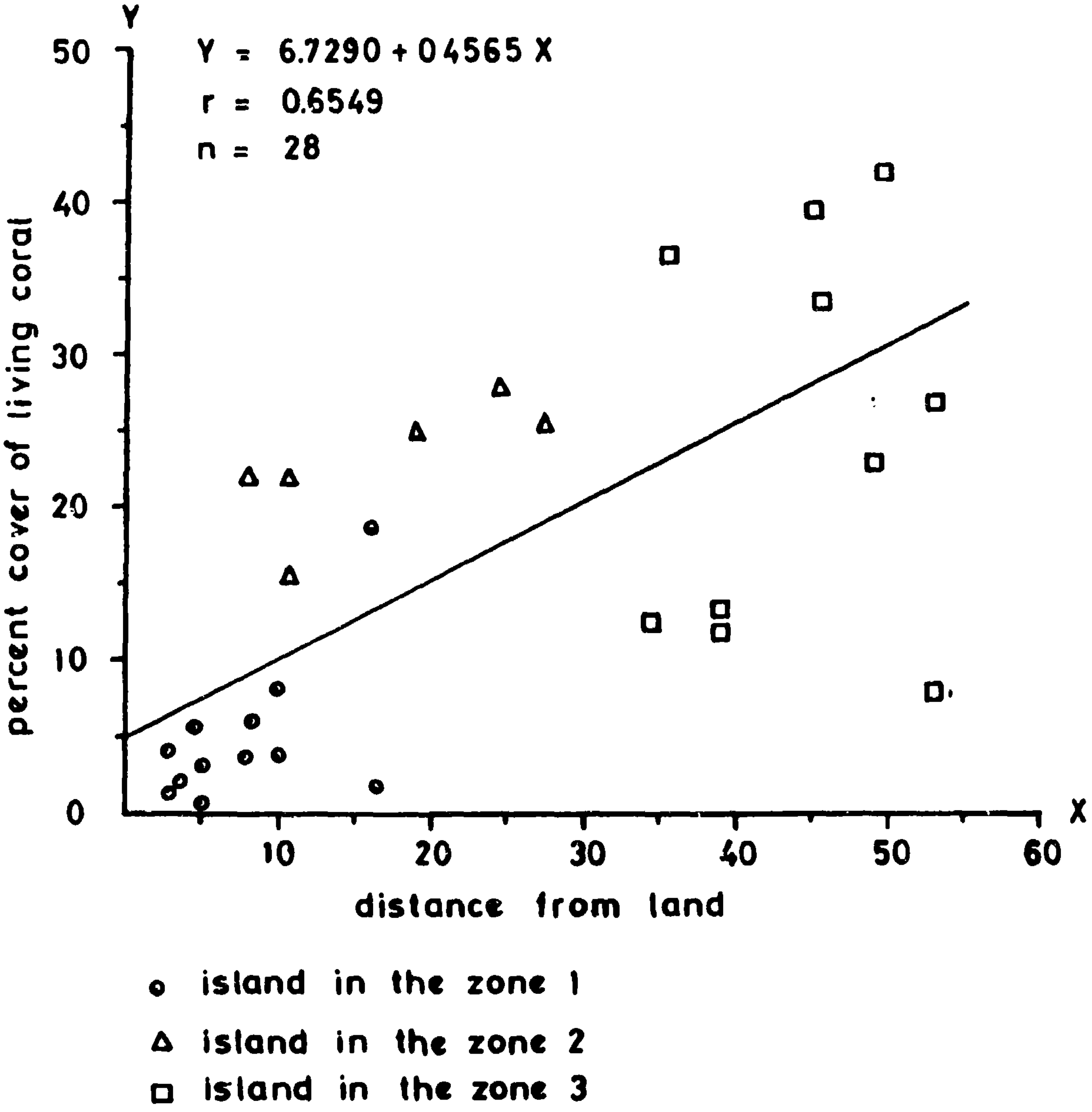


FIGURE 11.2 THE RELATIONSHIP BETWEEN PERCENT COVER OF LIVING CORAL ON THE REEF SLOPES OF TRANSECTED ISLANDS AND DISTANCE FROM LAND

Amesbury (1978) and Tay and Khoo (1984) mentioned that the physiography of the bottom is a major factor in determining fish distribution and abundance. In a coral reef ecosystem the benthic condition is assumed to be analogous to coral coverage. Based on this assumption, the results of this study support the above statement. Figure 11.3 shows a positive correlation between percent cover of living coral and number of fish species on the reef slope. The higher the percent cover of living coral, the higher the number of fish species that inhabit it.

Chaetodontids tend to limit their range to relatively small areas of the reef (Bardach 1958). The diversity of coral feeding chaetodontids has been found to be highest in areas with the greatest coral coverage in Guam (Jones and Chase 1985) and in Hawaii (Reese 1977 in Neudecker 1977). Therefore, coral feeding chaetodontids may be used as potential indicators of the health of coral reefs (Reese 1977 in Neudecker 1977). The result of the chaetodontid census shows that there is a positive correlation between percent cover of living coral and abundance of chaetodontids (Figure 11.4). This fact supports Reese's statement (in Neudecker 1977)on the use of chaetodontids as indicators of coral reef health.

Acknowledgements

The authors would like to thank Mr Yahmantoro and Harjatmo for their help in preparing the manuscript. The data of percent cover of living coral of the surveyed islands was supplied by Mr Suharsono of Lembaga Oseaonologi Nasional-LIPI and his permission for using this data is appreciated.

References

Amesbury, S.S. (1978). Studies on the biology of the reef fishes of Guam. University of Guam Marine Laboratory. Technical Report 49, 65pp.

Bardach, J.E. (1958). On the movements of certain Bermuda reef fishes. Ecology 39, 139-146.

Hutomo, M. and S. Martosewojo (1977). The fishes of seagrass community on the west side of Burung Island (Pari Island, Seribu Islands) and their variation in abundance. Mar. Res. Indonesia 17, 147-172.

Jones, R.S. and J.A. Chase (1975). Community structure and distribution of fishes in an enclosed high island lagoon in Guam. Micronesica 11, 127-148.

Neudecker, S. (1977). Development and environmental quality of coral reef communities near the Tanguisson power plant. University of Guam Marine Laboratory. Technical Report no. 41, 68pp.

Tay, S.W. and H.W. Khoo (1984). The distribution of coral reef fishes at Pulau Salu, Singapore. In: K. Sumawidjaja, S. Rahardjo and D.M. Sitompul (eds.). Recent research activities on coral reef in Southeast Asia. Biotrop Special Publ. No. 23, 27-40.

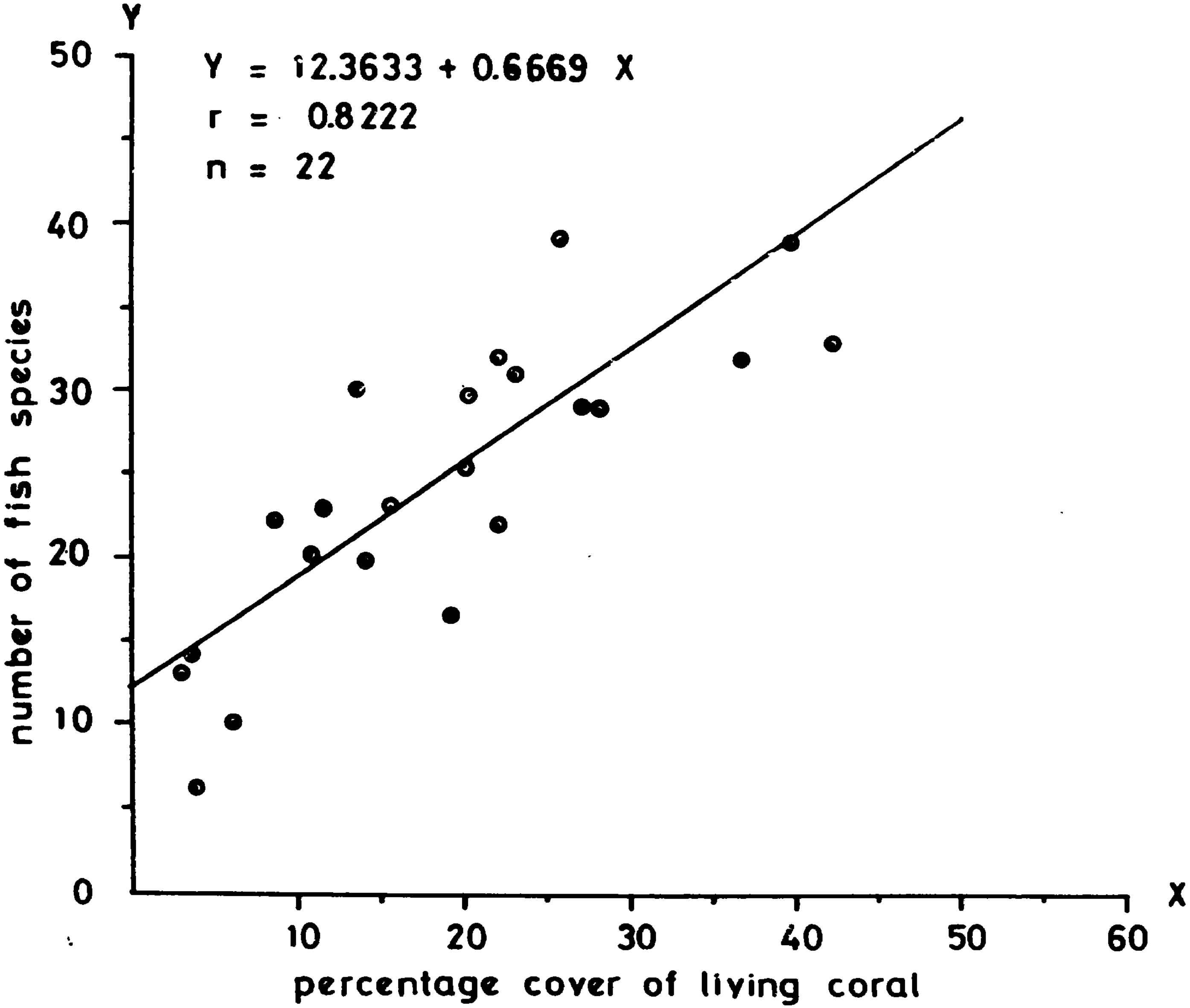


FIGURE 11.3 THE RELATIONSHIP BETWEEN NUMBER OF FISH ON THE REEF SLOPES OF TRANSECTED ISLANDS AND PERCENTAGE CORAL COVER

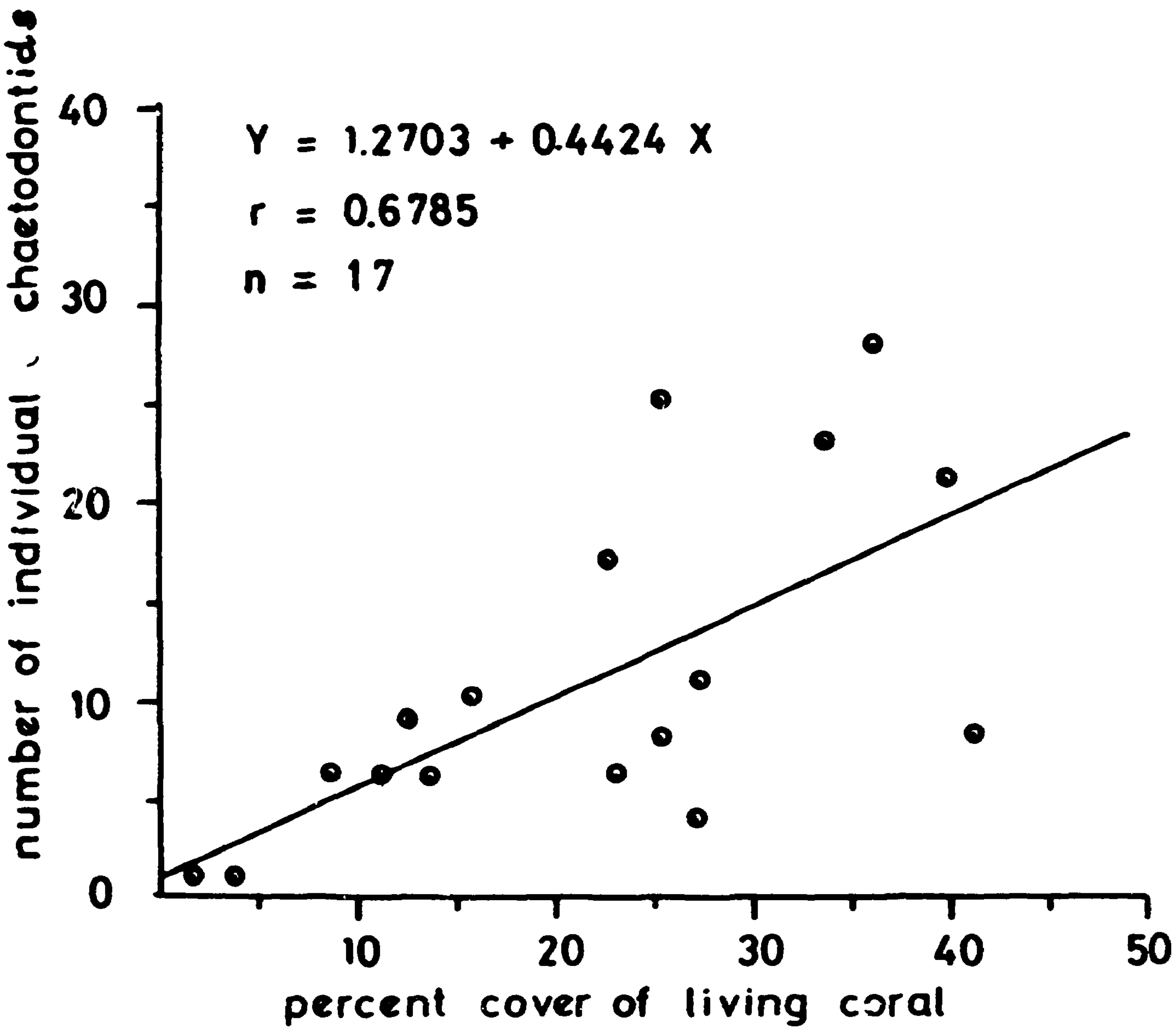


FIGURE 11.4 THE RELATIONSHIP BETWEEN CHAETODONTID ABUNDANCE ON THE REEF SLOPES OF TRANSECTED ISLANDS AND PERCENTAGE CORAL COVER

Appendix 11.1. Distribution of fishes on the reef slopes of the transected island reefs in the Bay of Jakarta and Seribu Islands. (+ indicates presence at a location; figures indicate number counted in transect area).

No.	Species	Occurrence and abundance: Location* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	HOLOCENTRIDAE																						
1.	*Holocentrus* sp.											+		+	+								
	CENTRISCIDAE																						
2.	*Aeoliscus strigatus*									+													
	FISTULARIIDAE																						
3.	*Fistularia vilosa*											+											
	APOGONIDAE																						
4.	*Apogon bandanensis*																			+			
5.	*Apogon* sp.									+													
6.	*Paramia quenquelineata*				+					+										+			
7.	*Sphaeramia orbicularis*																			+			
	SERRANIDAE																						
8.	*Cephalopolis argus*								+														
9.	*Cephalopolis miniatus*								+		3	3	2	4				2		1	4		3
10.	*Cephalopolis pachycentron*	+		+	+	1	4	1	1		2	1	5				2			1	2		
11.	*Epinephelus fuscoguttatus*																		1				
12.	*Epinephelus megachir*					1																	
13.	*Epinephelus merra*													1									2
14.	*Epinephelus summana*								1														
15.	*Epinephelus* sp.													1									
16.	*Plectropoma maculatum*								1		+							1				2	
	LUTJANIDAE																						
17.	*Lutjanus biguttatus*											9				1							
18.	*Lutjanus decussatus*		1	1			1	3	1		4	3	6	10	6		1	6	1	7	5	9	8
19.	*Lutjanus fulviflamma*		1					1				51	2			1					21	1	
20.	*Lutjanus Kasmira*							1			4		1										

Appendix 11.1 (continued)

No.	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Location* / Occurrence and abundance																						
	CAESIODIDAE																						
21.	*Caesio chrysozona*														+								
22.	*Caesio erythrogaster*					+			+			+	+		+	+	+					+	
23.	*Caesio* sp.				+																		
	SCOLOPSIDAE																						
24.	*Scolopsis bilineatus*		+					+	+		+		+	+	+	+	+	+	+		+		+
25.	*Scolopsis cancellatus*	+		+		+																	
26.	*Scolopsis ciliatus*	+		+	+	+	+											+					
27.	*Scolopsis margaritifer*	+	+	+			+	+	+		+	+	+	+	+			+	+	+	+	+	+
	NEMIPTERIDAE																						
28.	*Pentapodus setosus*																			+			
	PLECTHORHYNCHIDAE																						
29.	*Plectorhynchus chaetodontoides*							+															
30.	*Plectorhynchus lineatus*													+								+	
31.	*Plectorhynchus pictus*		+	+																			
	LETHRINIDAE																						
32.	*Lethrinus harak*		1												2							2	
33.	*Lethrinus kallopterus*										2	1	1		1					1	2		
34.	*Lethrinus* sp.														8								
	MULLIDAE																						
35.	*Parupeneus barberinus*										+												
36.	*Upeneus tragula*							+							+								
	PLATACCIDAE																						
37.	*Platax orbicularis*												10	1					+				+
	CHAETODONTIDAE																						
38.	*Chaetodon collare*												1										
39.	*Chaetodon kleini*																	1					

Appendix 11.1 (continued)

No.	Species	Location* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Occurrence and abundance																					
40.	Chaetodon lineolatus																			3		1	
41.	Chaetodon octofasciatus	+	+	+	+			9	10		8	28	13	6	3	6	7	6	4	13	6	4	17
42.	Chaetodon rafflesii												2				2		2				2
43.	Chaetodon triangulum		+					2									1		2	1			1
44.	Chaetodon trifasciatus							2												6			
45.	Chaetodon vagabundus														1								
46.	Chaetodon wiebeli					1	1						2										
47.	Chaetodon sp.																1						
48.	Chelmon rostratus			1							1											1	
49.	Heniochus acuminatus																						1
50.	Heniochus varius							4					2	2				1					
	POMACANTHIDAE																						
51.	Centropyge multipinnis												+	+	+								
52.	Chaetodontoplus mesoleucus										1	10	5			2	3	2		2	4	3	2
53.	Euxiphipops sexstriatus											3	+							1			
54.	Pomacanthus annularis			+										1									
55.	Pomacanthus sp.																			1			
56.	Pygoplites diacanthus											+											
	POMACENTRIDAE																						
57.	Abudefduf coelestinus					+	+		+		+	+		+	+	+	+	+	+			+	+
58.	Ab. saxatilis	+	+												+		+	+	+	+	+		+
59.	Ab. septemfasciatus					+	+												+				
60.	Amblyglyphidodon aureus										+												
61.	Amblyglyphidodon curacao							+	+		+	+	+	+	+	+	+	+	+	+	+	+	+
62.	Amblyglyphidodon leucogaster							+	+		+			+	+		+		+	+	+	+	+
63	Amphiprion clarkii																+				+		+
64.	Amphiprion ephippium											+				13	+	16		5			6
65.	Amphiprion melanopus												1				+		+				
66.	Amphiprion percula		+		+			8				+	3					4	+	3		+	
67.	Amphiprion polymnus	+																					
68.	Amphiprion sandaracinos													3				+	+				
69.	Chromis atripectoralis								+			+				+		+		+	+	+	+

Appendix 11.1 (continued)

No.	Species	Location* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Occurrence and abundance																					
70.	Dascyllus auranus		+						+														
71.	Dascyllus reticulatus								+								+						
72.	Dascyllus trimaculatus								+							+	+	+	+	+	+		+
73.	Dischistodus chrysopoecillus						+	+															
74.	Dischistodus melanotus										+						+	+		+			
75.	Dischistodus propoteaenia										+			+		+							
76.	Paraglyphidodon melas	+	+				+	+	+		+	+	+	+		+	+	+	+	+	+	+	+
77.	Plectroglyphidodon lacrymatus						+					+	+	+	+	+			+				+
78.	Pomacentrus argyreus											+											
79.	Pomacentrus tripunctatus					+		+	+								+			+	+		+
80.	Pomacentrus spp.				+					+													
81.	Premnas biaculeatus			+														+					
	LABRIDAE																						
82.	Choerodon anchorago											+							+				
83.	Cheilinus fasciatus										+	+	+	+	+	+			+	+	+	+	+
84.	Cheilinus trilobatus																						+
85.	Cheilinus undulatus										+	+	+										
86.	Coris sp.							+															
87.	Epibulus insidiator								+		+	+	+		+		+	+		+	+		
88.	Gomphosus varius							+								+							+
89.	Halichoeres albovitata								+						+								+
90.	Halichoeres argus			+																			
91.	Halichoeres gymnocephalus					+	+																
92.	Halichoeres hortulanus		+	+				+			+			+	+		+	+					+
93.	Halichoeres scapularis	+	+		+					+													
94.	Hemigymnus fasciatus										+				+			+					
95.	Hemigymnus melapterus							+	+			+	+	+		+	+	+	+	+	+	+	+
96.	Labroides dimidiatus	+	+	+	+		+	+	+		+	+		+		+							
97.	Thalassoma hardwicke										+			+		+					+		
98.	Thalassoma lunare		+		+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+
99.	Thallurus chlorurus					+		+							+		+			+	+	+	+

Appendix 11.1 (continued)

No.	Species																						
		Occurrence and abundance																					
	Location*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	SCARIDAE																						
100.	Scarus bicolor											+											
101.	Scarus blochii										+	+						+	+			+	
102.	Scarus dimidiatus											+	+	+					+	+	+		
103.	Scarus fasciatus		+	+			+	+					+	+	+				+	+			
104.	Scarus ghoban	+	+	+																			
105.	Scarus lunula											+	+								+		+
106.	Scarus madagascariensis								+		+		+					+					+
107.	Scarus margaritus							+					+					+	+				
108.	Scarus niger							+			+	+	+	+	+		+	+	+	+	+		+
109.	Scarus sordidusu													+									
110.	Scarus sp.				+			+															
111.	Scarus venosus														+								
	BLENNIIDAE																						
112.	Bleniid									+													
	SIGANIDAE																						
113.	Siganus corallinus							+					+	+						+	+	+	
114.	Siganus guttatus			+								+	+										
115.	Siganus virgatus		+	+							+	+	+	+	+	+		+	+		+		+
	ZANCLIDAE																						
116.	Sanclus canescens								+				5			+	1	7					
	ACANTHURIDAE																						
117.	Acanthurus lineatus							+															+
118.	Paracanthurus hepatus																		+				
	SCORPAENIDAE																						
119.	Pterois zebra											+											
	BALISTIDAE																						
120.	Balistapus sp.																	+					

Appendix 11.1 (continued)

No.	Species	Location*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
			Occurrence and abundance																					
	ALUTERIDAE																							
121.	<u>Alutera</u> <u>scripta</u>																							

* 1. P. Damar Kecil
2. P. Dapur
3. P. Damar Besar
4. P. Air Kecil
5. P. Nyamuk Besar
6. P. Nyamu Kecil
7. P. Bokor
8. P. Lancang
9. P. Onrus
10. P. Semak Daun
11. P. Kotok Besar
12. P. Ayer
13. P. Tikus
14. P. Tidung Besar
15. P. Hantu Besar
16. P. Hantu Kecil
17. P. Jukung
18. P. Sepak Besar
19. P. Putri
20. P. Panjang
21. P. Kelapa
22. P. Belanda

Appendix 11.2. Distribution of fishes on the reef edge of the transected island reefs in the Bay of Jakarta and Seribu Islands. (+ indicates presence at a location; figures indicate number counted in transect area).

		Occurrence and abundance																	
No.	Species Location *	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	HOLOCENTRIDAE																		
1.	*Holocentrus* sp.							+											
	CENTRISCIDAE																		
2.	*Aeoliscus Strigatus*										+								
	SERPANIDAE																		
3.	*Cephalopolis miniatus*										1								
4.	*Cephalopolis pachycentron*	+			2		2			+			1					1	
5.	*Epinephelus merra*			3															
6.	*Plectropoma maculatum*															1			
	LUTJANIDAE																		
7.	*Lutjanus decussatus*		1	2			1	1		4					1	1		1	
8.	*Lutjanus fulviflamma*															1			
	SCOLOPSIDAE																		
9.	*Scolopsis bilineatus*			+	+			+	+	+	+	+			+			+	+
10.	*S. cancellatus*			+				+	+			+		+			+	+	
11.	*S. margaritifer*				+		+			+	+				+	+		+	
	NEMIPTERIDAE																		
12.	*Pentapodus caninus*			+											+				
	LETHRINIDAE																		
13.	Lethrinus harak									6									
14.	*Lethrinus kallopterus*									2									
	MULLIDAE																		
15.	*Upeneus tragula*									+									

Appendix 11.2 (continued)

No.	Species	Location * 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Occurrence and abundance																	
	CHAETODONTIDAE																		
16.	*Chaetodon lineolatus*															+			
17.	*Chaetodon octofasciatus*			10	7		10	25	6	1	13	4	7	11	7	10	9	7	11
18.	*Chaetodon rafflesii*									1									
19.	*Chaetodon speculum*									1									
20.	*Chaetodon triangulum*														2	1			1
21.	*Chaetodon trifascialis*														1				2
22.	*Chaetodon trifasciatus*															3			
23.	*Chaetodon vagabundus*									1									
24.	*Chaetodon* sp.				4														
	POMACANTHIDAE																		
25.	*Centropyge septipinnis*									1									
26.	*Chaetodontoplus mesoleucus*						1	2	2								+	+	
	POMACENTRIDAE																		
27.	*Abudefduf coelestinus*		+		+				+	+		+	+	+			+	+	+
28.	*Ab. saxatilis*							+			+	+	+	+	+				
29.	*Ab. septemfasciatus*	+	+	+	+			+	+	+					+		+	+	+
30.	*Ambly. curacao*			+			+	+										+	+
31.	*Ambly. leucogaster*																	+	
32.	*Amphiprion ephippium*															+		+	
33.	*Amphiprion percula*						+										+		
34.	*Dascyllus trimaculatus*											+					+		
35.	*Dischistodus chrysopoecillus*			+															
36.	*Disch. melanotus*						+	+	+				+	+				+	+
37.	*Disch. prosopotaenia*			+															
38.	*Paraglyphidodon melas*			+			+	+	+		+		+	+	+	+	+	+	+
39.	*Plectroglyphidodon lacrymatus*				+		+	+	+			+	+	+	+	+	+	+	+
40.	*Pomacentrus atripectoralis*				+		+	+	+		+		+	+	+				+
41.	*Premnas biaculeatus*						+					+	+						
42.	*Premnas flavicuda*										+								
43.	*Premnas tripunctatus*	+	+	+				+			+			+			+	+	

Appendix 11.2 (continued)

No.	Species	Location * 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		Occurrence and abundance																	
	LABRIDAE																		
44.	Chaerodon anchorago		+												+				
45.	Cheilinus fasciatus									+								+	
46.	Cheilinus trilobatus									+									
47.	Epibulus insidiator			+				+		+								+	+
48.	Gomphosus varius										+			+	+		+		
49.	Halichoeres albovitata	+	+	+													+		+
50.	H. gymnocephalus		+	+			+									+	+	+	
51.	H. hortulanus			+			+			+	+		+	+	+				+
52.	H. marginatus			+	+		+												
53.	Hemigymnus melapterus			+				+							+		+		+
54.	Labroides dimidiatus			+	+		+					+	+						
55.	Stetojulis interupta										+								
56.	Stetojulis strigiventer			+															
57.	Thalassoma hardwicke			+			+	+	+			+		+			+	+	
58.	Thalassoma lunare		+	+	+		+	+		+	+	+	+	+	+	+	+	+	+
59.	Thaliurus chlorurus				+														
	SCARIDAE																		
60.	Scarus bicolor				+														
61.	S. blochii									+									
62.	S. fasciatus									+	+								
63.	S. madagascariensis						+	+											
64.	S. margaritus						+	+							+	+			+
65.	S. niger							+											
	SIGANIDAE																		
66.	Siganus corallinus															+			
67.	Siganus guttatus			+															
68.	S. virgatus								+						+	+		+	
	ZANCLIDAE																		
69.	Zanclus canescens							1		+									

Appendix 11.2 (continued)

No.	Species																		
		Occurrence and abundance																	
	Location *	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	ACANTHURIDAE																		
70.	*Acanthurus glucopareius*																+		
71.	*Acanthurus lineatus*								+	+									

* 5. P. Nyamuk Besar
6. P. Nyamuk Kecil
7. P. Bokor
8. P. Lancang
9. -
10. P. Semak Daun
11. P. Kotok Besar
12. P. Ayer
13. P. Tikus
14. P. Tidung Besar
15. P. Hantu Besar
16. P. Hantu Kecil
17. P. Jukung
18. P. Sepak Besar
19. P. Putri
20. P. Panjang
21. P. Kelapa
22. P. Belanda

CHAPTER TWELVE

MAN-MADE FLOTSAM ON THE STRAND-LINES OF THE THOUSAND ISLANDS (KEPULAUAN SERIBU) JAKARTA, JAVA

N.G. Willoughby
University of Diponegoro
Semarang
Indonesia

Introduction

Human induced damage to coral reefs comes in many forms, ranging from the widespread destruction caused by mining coral for building purposes or death by chemical pollution, to the smaller scale or more localised damage by fishermen's anchors, tourism and scientific collections.

One of the objectives of this workshop was to investigate the environmental gradients which might affect the coral reefs around Jakarta. These could reasonably be expected to be demonstrated between the inshore waters of Jakarta Bay and the offshore waters of the outer islands of the Thousand Islands (Kepulauan Seribu) to the north west of Jakarta, Java. It was anticipated that coral damage and death would be greatest close to Jakarta, and would become less the farther from the city that sampling was carried out.

In addition to the oceanographic and coral reef health indices collected by the team, an environmental parameter which was unfortunately very visible on some islands was also measured - that of man-made strand-line pollution. Man-made items such as slowly degraded plastics, polythene and rubber products collect as slowly degraded plastics, polythene and rubber products collect as flotsam along island strand-lines, and provide an easily visible cumulative index of pollution. It was thought that such a measurement would provide interesting data on the dispersal of floating rubbish from the city of Jakarta, and might also be related to the state of the coral reefs along the island chain.

METHODS

Strand-lines around the islands of Kepulauan Seribu are usually well defined, although they were absent for the purposes of this technique around islands with major fringing mangrove areas. The identifiable strand-line was often as narrow as 1m, but in situations where it was more diffuse, such as in multiple coral ramparts, a band of no more than 5m in width was used.

A 50m length of the strand-line was measured, and the items of man-made flotsam (ie rubbish) along this line or band counted. The categories used were:- plastic bags; expanded polystyrene blocks of 10cm diameter or larger; footwear, predominantly 'flip-flops' or 'thongs', but including all types; bottles, usually plastic but occasionally glass; tins; lamp bulbs; and fishing gear such as ropes or nets. The presence of tar spots or tar balls was also noted when they occurred.

The transects were made at regular intervals around the strand-line of each island, allowing from 50m to 250m spacing between them depending on island size. Satisfactory reproducibility of the counts was confirmed early in the survey by repeated sampling around Pulau Sakit (Bidadari).

Results and Discussion

Twenty four islands in the Kepulauan Seribu chain were examined between May 6-18th 1985. Details of their chart locations, sizes, populations and distances from mainland Java are given in Table XII.1.

a) Man-made Flotsam

The numbers of each category of rubbish per transect were converted to figures for rubbish per metre, and are shown in Table XII.2. Three of the categories, polythene bags, polystyrene blocks and footwear, were found to have consistently high counts, often several per metre on the inner islands, with the total of all the other categories (bottles, tins, ropes and light bulbs) usually an order of magnitude lower. The figure for the total rubbish per metre of strand-line on each island has been plotted against the distance of the island from the mainland, and is given in Figure 12.1, which shows the two to be inversely related.

While some of the rubbish, especially in such heavily populated islands as P. Harapan (Kelapa), is likely to be locally generated, most probably originates either from Jakarta itself, or from the River Sadane, which discharges just south of P. Kokor, to the west of Jakarta. A mainland source is also indicated by the large clumps of Eichornia, the freshwater hyacinth, which were found in the sea with rubbish slicks as far north as P. Pari and P. Tikus. Anomalies are, nevertheless, likely to be present in the data as a result of human activities on the islands themselves. More than the expected amount of rubbish may be present, as was obviously the case around the densely populated P. Harapan; or less, as on P. Sakit (Bidadari) and P. Putri, where the islands' managers regularly clear the beaches of rubbish to enhance their tourist potential.

A total rubbish count was used, rather than considering the three most important items individually, because of the zonation of these items across the strand-line and their affinities for different coastal states or conditions. The polystyrene, being very light, was always found at the top of the strand-line; the polythene bags, which barely float, were usually found at the bottom, with the footwear in the intermediate zone. Furthermore, beaches fringed with mangroves or tree roots exposed by erosion (often the northern shores) produced higher than average polythene bag counts, (while scalloped beaches tended to retain polystyrene blocks and footwear.

Can this surface measurement, however, be a useful indicator of the state of the coral reefs below water? A strong negative correlation was found between the amount of rubbish on an island beach and the living coral cover or species diversity indices for the reefs around the northern shores of that island. As the floating rubbish itself can not be considered to be a pollutant of the reef, the above and below water indices must be correlated through a third factor which they both measure - human activity.

This survey therefore succeeded in showing that strand-line rubbish counts could provide a simple method of quantifying the effects of human activity, and with it the likely state of the coral reefs around Kepulauan Seribu.

b) Tar Spots and Balls

Tar spots were frequently seen during the survey, with 72 out of the 184 transects being affected (i.e. 39%), with tar spots observed on 15 of the 24 islands examined). Tar balls, or to be more precise, the 'platforms' formed during their breakdown, were much less common, with only 24 transects affected (i.e. 13%) on 9 of the islands.

This pollution has been plotted as the percentage of transects on which the spots or balls were found against the island's distance from the port of Jakarta, Tangjug Pirok (figure 12.2). While tar balls show no obvious trend in their distribution, the tar spots occur much more frequently as the proximity of islands to the oil fields in the north west of Kepulauan Seribu is reduced. The nearest oil platform in this field is 'Rama B', which is situated 30km north west of P. Putri.

The relationship of tar pollution to the distance of the islands from the nearest land was therefore virtually the reverse of that shown for the floating domestic rubbish, and the data imply that the most likely source of oil on the islands' beaches is the north western oil fields. This possibility is also supported by the fact that virtually all the tar balls and 'platforms' were found on the northern shores of the islands.

TABLE XII.1 <u>Islands visited during survey*</u>

Island No.	Island Name	Chart Ref. Lat°S	Long°E	Circumf. (Approx) (m.)	Population (Households) (Approx)	Distance from mainland (km)
1	Nyamuk Besar	6.02.00	106.51.00	200	0	7
2	Nyamuk Kecil	6.00.30	106.50.00	200	1	10
3	Damar Kecil	5.59.00	106.51.00	700	10	11
4	Damar Besar	5.57.30	106.51.00	2200	20	15
5	Ayer Besar	6.00.30	106.47.00	1000	10	8
6	Cipit (Kayangan)	6.02.00	106.44.00	600	10	2
7	Kepal (Undrus)	6.02.30	106.44.00	1050	10	2
8	Rakit (Bidadari)	6.02.00	106.45.00	1100	20+ tourism	4
9	Ubi Besar	6.00.00	106.44.30	50	0	5
10	Untung Jawa	5.58.30	106.42.30	2500	100	5
11	Dapur	5.55.30	106.43.30	250	0	11
12	Bokor	5.56.30	106.38.00	1900	0	8
13	Lancang Besar	5.56.00	106.35.00	3000	50	10
14	Tikus	5.52.00	106.35.00	750	1	17
15	Pari	5.52.00	106.37.00	3000	100	18
16	Semak Daun	5.42.30	106.34.00	700	1	33
17	Kotok Besar	5.42.00	106.32.00	2900	10	34
18	Harapan (Kelapa)	5.39.00	106.34.00	2500	1000	39
19	Pamjang	5.38.30	106.33.30	2400	5	41
20	Belanda	5.37.00	106.36.30	300	0	45
21	Putri	6.36.00	106.33.30	1100	20+ tourism	46
22	Sepa	5.34.00	106.35.00	1050	10	49
23	Hantu Kecil	5.32.30	106.32.00	1600	0	52
24	Hantu Besar	5.32.00	106.32.30	1750	0	53

* Island names, chart references and distances from land have been obtained largely from chart "Pantai Utara Jawa (Lembar I) Tanjung Cigoneng Hingga Tanjung Priok, 1:200,000". Circumferences were measured while walking round each island, and the number of households estimated at the same time.

TABLE XII.2

Frequency of occurrence of man-made flotsam on island strand-lines

Island No.	Island Name	No. of transects (50m each)	No. of items of rubbish per m strand-line: Polythene bags	Polystyrene blocks	Footwear	Bottles	Tins	Ropes	Lamp bulbs	Total Rubbish per m strandline ± SD
1	Nyamuk Besar	4	3.2	3.1	1.7	0.3	0.2	+	+	8.5 ± 3.1
2	Nyamuk Kecil	1	1.8	4.8	3.4	0.3	0.2	+	+	10.5
3	Damar Kecil	4	0.4	2.3	2.3	0.2	0.2	+	+	5.5 ± 3.0
4	Damar Besar	9	0.6	1.1	2.0	0.2	0.2	+	+	4.1 ± 1.9
5	Ayer Besar	7	3.5	2.3	2.1	0.5	0.3	+	+	8.7 ± 2.6
6	Cipit (Kayangan)	5	0.7	1.9	1.3	0.2	0.2	+	+	4.3 ± 0.6
7	Kepal (Undrus)	7	2.1	1.9	2.5	0.1	0.1	+	+	6.7 ± 4.4
8	Rakit (Bidadari)	11	2.5	0.7	0.5	0.1	0.1	+	+	3.9 ± 1.2
9	Ubi Besar	1	1.3	2.3	5.1	0.9	0.5	+	+	10.2
10	Untung Jawa	10	5.2	1.5	2.5	0.1	0.1	+	+	9.9 ± 6.8
11	Dapur	5	0.3	0.4	0.6	0.2	0.1	+	+	1.7 ± 0.7
12	Bokor	8	6.4	1.4	2.3	0.1	0.1	0.1	+	10.4 ± 3.0
13	Lancang Besar	1	2.9	1.2	1.7	0.2	0.1	+	-	6.2
14	Tikus	5	0.5	0.2	0.3	0.1	+	+	-	1.1 ± 0.3
15	Pari	21	0.5	0.3	0.5	+	+	0.1	+	1.4 ± 0.5
16	Semak Daun	4	0.1	0.1	0.2	+	+	+	+	0.4 ± 0.3
17	Kotok Besar	11	0.3	0.1	0.1	+	+	+	+	0.6 ± 0.6
18	Harapan (Kelapa)	3	0.7	+	+	+	+	0.1	+	0.9 ± 0.8
19	Panjang	16	0.1	0.1	0.1	+	+	+	+	0.3 ± 0.2
20	Belanda	1	-	+	+	-	+	+	-	0.1
21	Putri	7	+	+	+	+	-	+	-	0.1 ± 0.1
22	Sepa	21	+	+	+	+	+	+	+	0.1 ± 0.1
23	Hantu Kecil	11	+	+	+	+	+	+	+	0.1 ± 0.1
24	Hantu Besar	12	+	0.1	+	+	-	+	+	0.1 ± 0.1

+ Present at <0.05 items/metre; - Absent

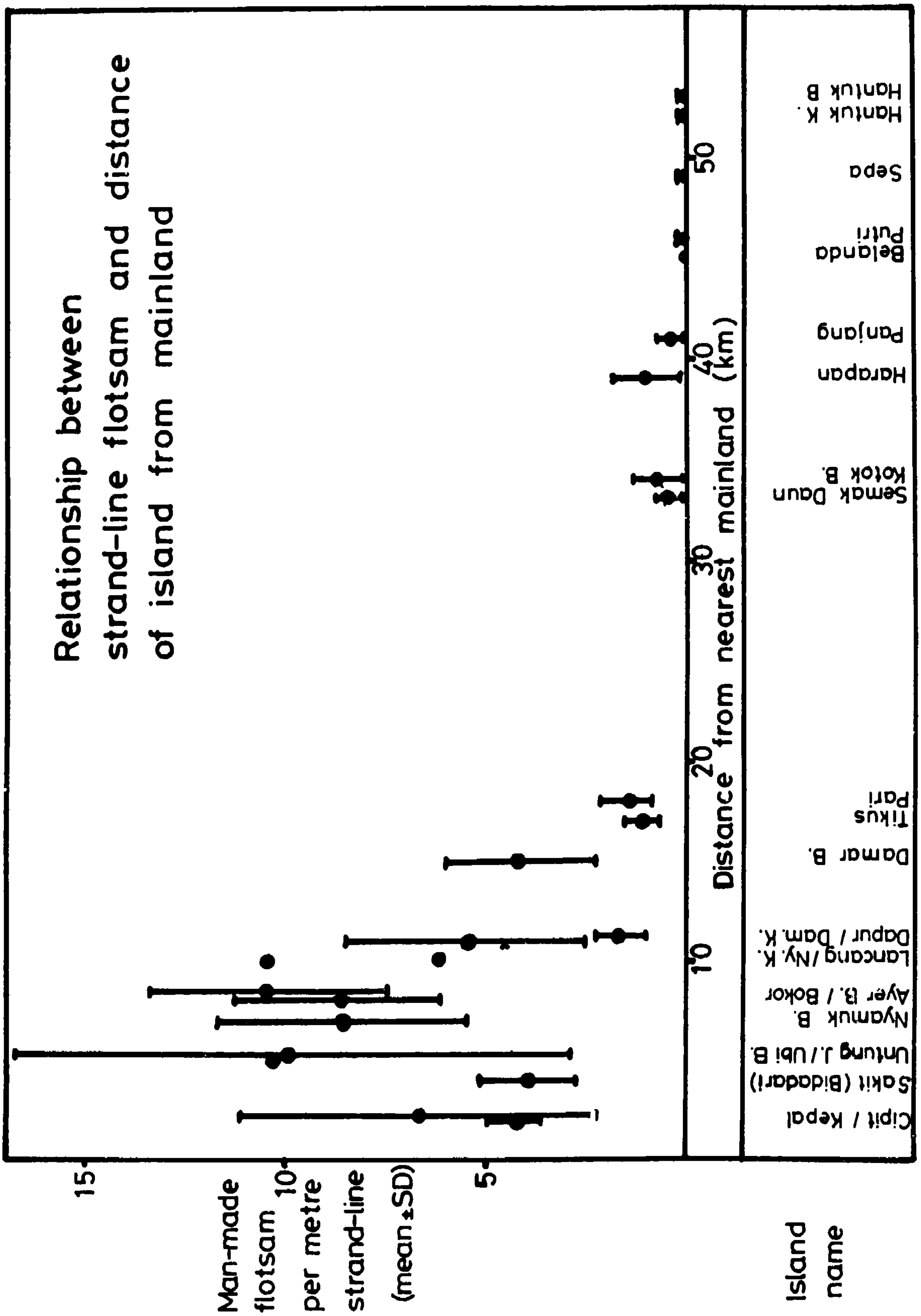


FIGURE 12.1 RELATIONSHIP BETWEEN STRANDLINE FLOTSAM AND DISTANCE OF ISLAND FROM MAINLAND

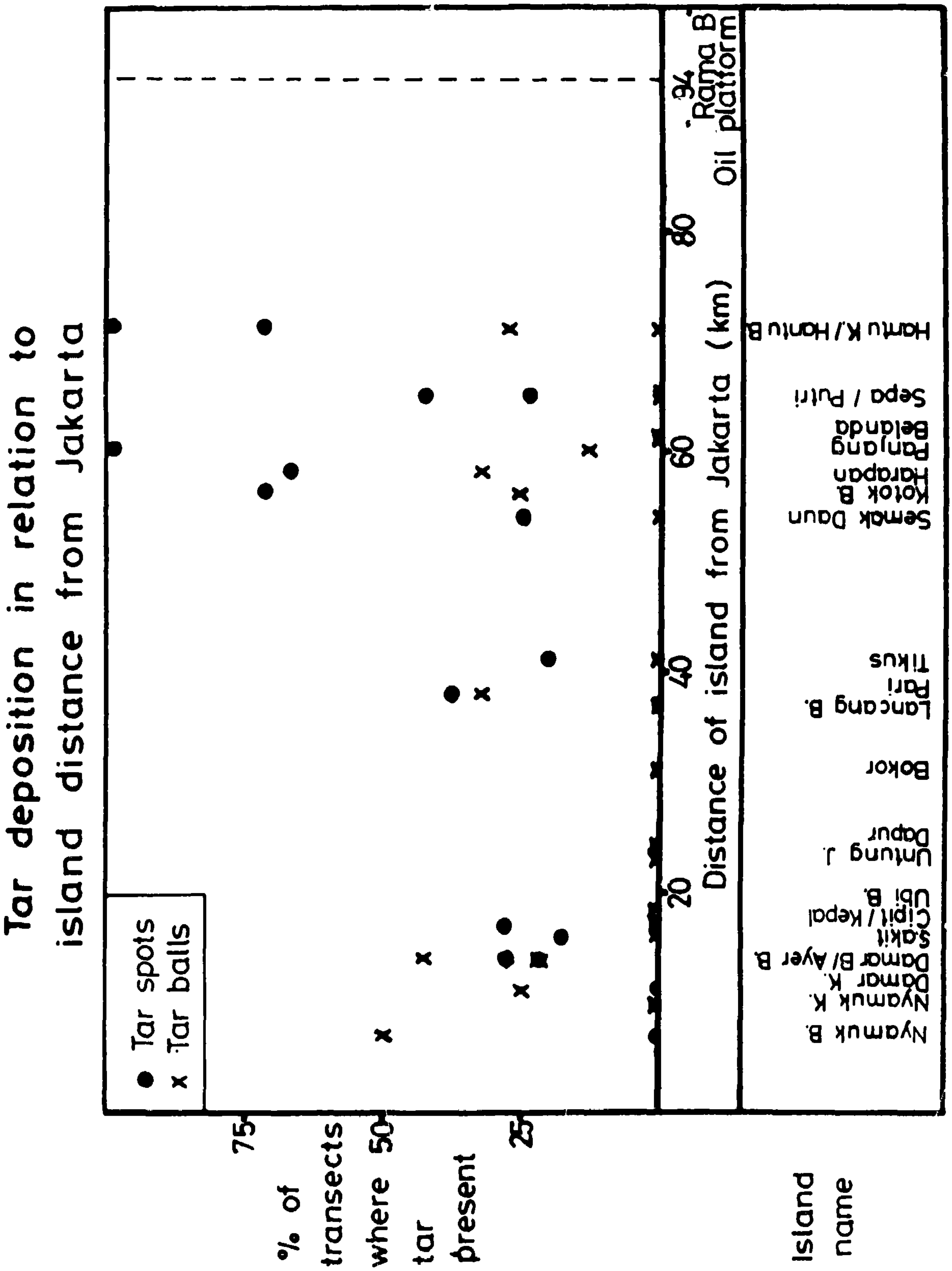


FIGURE 12.2 TAR DEPOSITION IN RELATION TO ISLAND DISTANCE FROM JAKARTA

CHAPTER THIRTEEN

RESPONSES OF CORAL REEF COMMUNITIES TO ENVIRONMENTAL VARIBALES IN THE KEPULAUAN SERIBU ISLAND CHAIN

J. Robin E. Harger, Ph.D
Programme Specialist
Unesco-ROSTSEA
Jakarta, Indonesia

Introduction

A preliminary survey of the Jakarta Bay Kepulauan Seribu was carried out by the Indonesian Institute of Oceanography (LON-LIPI) and Unesco in March 1985. This survey showed that coral reefs in the Jakarta Bay area were degraded and the information gathered was then used to plan the sampling stations used in the current workshop. During this activity a total of twenty five participants spent thirteen days in the Kepulauan Seribu area gathering data for the purpose of assessing the effects of human induced impact on coral reefs of the area and associated environmental trends.

The workshop gathered approximately 550 man-days of data concerning coral reef structure in the Kepulauan Seribu region to establish a comprehensive coral reef data base. This paper describes part of the resultant data base and attempts to provide preliminary analysis of some features.

At the present time the data base consists of records of coral reef structure obtained at two depths (roughly 1 meter and 3 meters below the mean tidal level) from the north face of approximately 28 islands. Additional measurements were made of physical environmental factors such as: secci disk extinction depth, surface and 3 meter salinity and temperature. Estimates of the concentration of driftline debris were also made for most of the islands and additional items of information such as population density, island circumference, distance from the mainland, distance from Jakarta etc. were recorded.

In the case of the biological indicators of population structure, two basic methods of investigation were applied to sessile communities and two slightly different procedures used for the assessment of fish populations. For sessile communities two groups of participants gathered data utilizing three 60 m line intercept transects, parallel to the shoreline at each of the two depths mentioned previously (1 m and 3 m). One of these groupds dealing with sessile organisms utilized a method proposed by the Australian Institute of Marine Science (AIMS) which consists of subdividing coral assemblages according to categories, characterised by some agreed upon criteria, based on the life-form of the corals. Thus categories such as coral-massive, coral branching, turf algae etc. are used. The second group of investigators utilized 60 m replicated line intercept transects but identified each hard coral to the species level and recorded colony sizes together with measurements on the additional flora and fauna encountered. Part of the rationale of the exercise was to test under field conditions the capability of the resulting data sets in order to be guided in making choices for a reginal standardisation in data acquisition relating to coral reef community structure.

It was initially proposed that separate transects be utilized for both the above studies however, in consideration of time available, both groups worked from the same transect lines after the first few islands were sampled. At least one investigator however, maintained separate transects at the 1 meter depth.

The resulting data sets are recorded in two ways:

1) In the form of a matrix with records (rows) representing transects (identified by Island) and fields (columns) representing the separate data elements recorded over the transect i.e. percentage cover on an individual species or life-form basis, physical measurements etc. The resulting matrix presently contains approximately 19,000 records in 117 fields and covers 28 islands.

2) In the form of a data set in which individual species of hard corals are identified together with associated colony sizes encountered on each transect covered. This material consists of some 3,500 records and was assembled under the direction of Dr Hans Moll.

Altogether the resulting data base thus consists of over 22,000 records.

A list of field headings relating to the matrix mentioned in (1) above is presented in table 1 to indicate the breadth of the information assembled.

Data set organisation

For the purpose of preliminary analysis relicates at each depth were compressed into one by taking the mean of each field. This procedure destroys the "among replicate" variance and reduces the overall number of degrees of freedom available for statistical analysis, however the resulting data set becomes more manageable particularly for detection of overall trends. for detailed hypothesis testing the original data set should be used.

Comparisons between survey methods

A major goal of the activity was to compare the results obtained through the use of the life-form survey as propounded by the Australian Institute of Marine Science (AIMS), with those arising through application of more traditional species/intercepts/transect methods.

To focus on the two methods Dr Hans Moll from Rijkmuseum Van Natuurlijke Historie, P.O. Box 9517, 2300 RA Leiden, the Netherlands organised the traditional species intercept work together with Mr Suharsono of LON. Dr Barbara Brown of the University of Newcastle Upon Tyne, England and Dr Sukarno of LON also took part in the generation of species/line intercept data independently for the shallow transects only.

Dr D Kinsey and Mr L. De Vantier of The Australian Institute of Marine Science (AIMS) supervised the life-forms survey. Table 2 shows an example of the resulting data set gathered from one of the islands investigated (Pulau Ayer).

Percent living cover and percent cover by scleractinian corals are the two main parameters that are estimated both by the life forms method and the species intercept method. Data relating to these factors are used here to form the basis for a primary comparison of the results obtained by each method.

Using the compressed data set mentioned above and considering both depths (with untransformed data) the mean percentage cover for the species intercept method supervised by Dr H Moll was y = 14.79 s = 12.64 n = 54 and for the growth forms y = 17.34 s = 13.19 n = 56. These values are not significantly different from one another. Using a matched pairs t test there is again no significant difference between these data sets. In the case of the shallow transects however, the mean % cover data obtained by Dr B brown (y = 5.47) is marginally larger than that obtained by Dr H Moll (y = 3.66) P<0.05>0.01 t = 2.7 df = 12 using a matched pairs t test comparison. However, the figures obtained by Brown are not significantly different from the life forms data (y = 7.69) taken over the same 13 transects for coral cover. A correlation coefficient of 0.717 is obtained between the species intercept percentages and the life forms percentages estimates with n = 46. A correlation coeficient, r2, of 0.865 was found for the case of Brown's species intercept percent cover data and the life forms percentages estimates with n = 13.

When a matched pairs t test comparison is made in the case of percent living cover for all depths however, a different picture emerges in that the mean of 54 transect sets obtained by the sepcies intercept method (H Moll) y = 18.88 is only one quarter of the size of the life forms estimate (y = 81.47). This is presumably because all living material is scored in some way by the life forms method whereas traditional species intercept approaches usually leave out the conspicuous items such as "algal film".

The results so far would seem to indicate that application of either of the foregoing methods results in approximately the same data being gathered for coral cover estimates. However, this is not quite the case as indicated by the correlation coefficient which is 0.77. A further indication of this anomaly was found when the overall data set was subjected to varioius forms of orthogonal and oblique factor analyses in order to determine soemthing of the structure present in the data. In the majority of approximately 50 analyses the estimation for percentage coral cover by the species intercept method was usually found to load on a different factor than that occupied by the growth forms percentage coral cover estimate when both were included in the same analysis.

In conclusion it may be stated that the two methods measure something similar but not identical in their application. The exact nature of the differences could be further examined by using the full data set. However, it is not certain that a 1:1 identity has been reliably preserved at the replicate/treatment level in collating the final data sets.

At this stage there would seem to be no good basis for choosing one method as opposed to the other for the purpose of general coral reef assessment except that the life forms method is more convenient to apply since extensive taxonomic knuwledge is not required on the part of field workers.

Detecting patterns amongst variables relating coral reef population structure

Factor-analysis is perhaps the most intriguing form of analysis that can be applied to a data set such as the one generated from the Kepulauan Seribu region. originally developed as a mechanism to aid psychologists and social scientists structure responses to questionnaires and psychological tests, the method assumes that for related and thus correlated variables it is possible to visualize at least one factor whose influence is expressed by some linear combination of relevant variable values whenever the factor in question is active. Of course any particular variable measured in ordinary space may express its value as the result of influences exerted by more than one underlying factor and furthermore such factors may be orthogonal to one another their existence can readily by plotted in three dimensional space. Where more than three orthogonal factors are postulated the number of spatial dimensions must be increased in order to maintain a congruent representation. In essence factor analysis endeavours to identify factors as the independent elements of a multiple regression equation where the values of the dependent variable, the observed variable, under consideration are projected by the unknown independent factors.

During this investigation the technique of factor analysis using a principal components analysis followed by orthogonal and perhaps oblique rotations of the factor matrix usually with a varimax extraction, was used.

Perhaps the most serious case against the blanket application of the life-forms method is provided by the results obtained through factor analysis. In over 30 factor analyses this method clearly identifies a factor, often the majority factor, as being predominantly associated with various measures of species diversity (variables 3, 17, 18, 15 and 20) each of which are somewhat redundant. None of the life-form's variables (Table 2) loaded heavily on this factor. Thus one may conclude that some form of species assessment in conjunction with application of the life forms method is necessary and essential if this obviously real and important factor is to be addressed.

In other words the life-forms approach yields a wealth of interesting and informative data and its widespread application should be encouraged however, it does not by any means yield a complete picture of coral community structure by itself.

Conclusions

The analyses of the Pulau Seribu data suggest that a great deal of insight can be obtained into the structural responses of coral reef communities along the environmental trends between Jakarta Bay and the Kepulauan Seribu.

Because the available data base is so large, it is possible to think of many biologically and environmentally appropriate ways to stratify the material into meaningful subsets in order to look for environmental trends: i.e. outer islands, middle islands, inner or Jakarta Bay islands. Other subdivisions are also possible i.e. privately held island versus those with public access etc. Islands in the coastal transition zone, where water hyacinth outwashings break up, versus inner and outer islands etc. etc.

The available data does not readily answer a question posed in terms of defining the "best" sampling methods. All measured variables provide some insight into the communities and as such future surveys should endeavour to maximise the variables they cover, but should do so by working outward from a central core or agreed upon minimal subset.

I will conclude by saying the Kepulauan Seribu data set (Part 1 i.e. not including the majority of colony size measurements) can be obtained from Unesco-ROSTSEA on IBM 5 1/4" floppy disk format either as a DB-III file or a systems data format "comma" delimited file by sending a written request plus a blank diskette.

Table XIII.1

List of fields for DB-III reference file, containing Kepulauan Seribu Coral Reef Survey Data

1. Reef name
2. Site-type
3. Reef Number
4. Station
5. Depth
6. Live Cover % (HM)
7. Hard Coral Cover % (HM)
8. # Coral Species/transect (HM)
9. # Coral Colonies/transect (HM)
10. Acropora Branching-Individuals (I)
11. Acropora Branching (%)
12. Acropora Tabulate (I)
13. Acropora Tabulate (%)
14. Acropora Encrusting (I)
15. Acropora Encrusting (%)
16. Acropora Submassive (I)
17. Acropora Submassive (%)
18. Coral Branching (I)
19. Coral Branching (%)
20. Coral Massive (I)
21. Coral Massive (%)
22. Coral Encrusting (I)
23. Coral Encrusting (%)
24. Coral Sub-Massive (I)
25. Coral Sub-Massvie (%)
26. Coral Foliose (%)
27. Coral Foliose (I)
28. Soft Coral (I)
29. Soft Coral (%)
30. Gorgonian (I)
31. Gorgonian (%)
32. Sponge (I)
33. Sponge (%)
34. Other fauna (%)
35. Other fauna (%)
36. Acanthaster (I)
37. Acanthaster (%)
38. Macro Algae (I)
39. Macro Algae (%)
40. Turf Algae (I)
41. Turf Algae (%)
42. Coralline Algae (I)-patches
43. Coralline algae (%)
44. Halimeda (I)
45. Halimeda (%)

46. Algal Film (I)
47. Algal Fim (%)
48. Blue Algal Film (I)
49. Blue Algal Film (%)
50. Turf/Coralline Algae (I)
51. Turf/Coralline Algae (%)
52. Algal Association (I)
53. Algal Association (%)
54. Sand (I)
55. Sand (%)
56. Rubble (I)
57. Rubble (%)
58. Sand/Rubble (I)
59. Sand/Rubble (%)
60. Silt (I)
61. Silt (%)
62. Dead Coral (I)
63. Dead Coral (%)
64. Total Scleractinia (I)
65. Total Scleractinia (%)
66. Total Acropora
67. Total Acropora
68. Total Non Acropora
69. Total Non Acropora
70. Total Soft Coral (I)
71. Total Soft Coral (%)
72. Total Sponge (I)
73. Total Sponge (%)
74. total Other Fauna (I)
75. Total Other Fauna (%)
76. Total Algae (I)
77. Total Algae (%)
78. Total Abiotic (I)
79. Total Abiotic (%)
80. Total Live (I)
81. Total Live (%)
82. Secci disk extinction (M)-TS
83. Distance from Mainland (KM)
84. Distance from Tanjung Priok (KM)
85. Surface Salinity (TS)
86. Three Meter Salinity (TS)
87. Surface Temperature (TS)
88. Three Meter Temperature (TS)
89. Estimated Coral Cover (TS)
90. Estimated Diadema Cover (TS)
91. Estimated Disturbance Scars/100M (RH)
92. All Rubbish/meter strandline (NW)
93. Polyethylene Bag/M.strandline (NW)

94. Polyethylene Blocks/
M Strandline (NW)

95. Footware/M.strandline (NW)

96. Island Population (Est)(Various)

97. Island Circumference (Various)

98. Estimated Maximum Depth Corals (Various)

99. Estimated Maximum Coral Species

100. # Fish Species (H)

101. # Chaetodontid species (H)

102. # Chaetodontid individuals (H)

103. # Serranid Species (H)

104. # Serranid individuals (H)

105. # Lutjanid species (H)

106. # Lutjanid Individuals (H)

107. # Chaetodontid individuals (GBRMPA)

108. # Serranid Individuals (GBRMPA)

109. Total Coral Species per transect (HM)

110. Coral Species Diversity H'(log) (log 10) (from data HM)

111. Mean colony size P. lichen (HM)

112. Mean colony size P. lutea (HM)

113. Mean colony size P. nigrescens (HM)

114. Coral Cover % (IM) (BB)

115. Mean colony size P. lobata (HM)

116. Total Coral Species seen per station(HM)

117. Total Coral Species seen per station (S)

I = Individuals or individual readings

HM = Hans Moll

H = Hutomo

S = Sukarno

NW = Nick Willoughby

GBRMPA = Great barrier Reef Marine Park Authority - D. Kinsey

BB = Barbara Brown

RH - Robin Harger

TS = Terry Scoffin

Notes: fields 10-81 represent data collected through use of the life-forms approach (AIMS method).

Table XIII.2

Percentage cover and number of occurrences of benthic life form categories recorded from a 60m line transect. Output generated by AIMS software on a per-station basis for life-forms survey data.

Reef Name:	P:AYER	Site description:	NFLAT
Reef Number:	0	Station Number:	18A1
Date Sampled:	05/14/85	Transect Depth:	1

BENTHIC LIFE FORM	CATEGORY	CODE	No. OF OCCURRENCES	PERCENT COVER
Acropora	Branching	ACB	2	3.4
	Tabulate	ACT	0	0.0
	Encrusting	ACE	0	0.0
	Submassive	ACS	0	0.0
Non-*Acropora* corals	Branching	CB	3	5.1
	Massive	CM	1	1.6
	Encrusting	CE	3	0.8
	Submassive	CS	5	1.2
	Foliose	CF	4	2.2
Soft Corals		SC	1	0.5
Gorgonians		GO	0	0.0
Sponge		SP	5	2.0
Other	(General)	OT	3	3.0
	Acanthaster planci	OTA	0	0.0
Algae	*Macro*	MA	6	1.4
	Turf	TA	23	70.1
	Coralline	CA	6	8.8
	Halimeda	HA	0	0.0
	Film	FA	0	0.0
	Blue Film	BFA	0	0.0
	Turf & Coralline	TACA	0	0.0
	Algal assemblage	AA	0	0.0
	Sand	S	0	0.0
	Rubble	R	0	0.0
	Sand & Rubble	SR	0	0.0
	Silt	SI	0	0.0
	Dead Coral	DC	0	0.0

TOTALS

	No. OF OCCURRENCES	PERCENT COVER
Scleractinia	18	14.2
Acropora	2	3.4
Non-*Acropora* corals	16	10.9
Soft Corals	1	0.5
Sponges	5	2.0
Other Fauna	3	3.0
Algae	35	80.2
Abiotic	0	0.0
Living	62	100.0

SUMMARY

The survey of the island reefs in the Bay of Jakarta and Kepulauan Seribu indicated several interesting points:-

a) That many of the reefs in Jakarta Bay had deteriorated since the original surveys of Umbgrove over 50 years ago, although some reefs showed relatively high diversity and cover of corals.

b) That the configuration of many of the islands resurveyed during the workshop had altered significantly over time and that some of the islands had either disappeared or were in the process of disappearing as a result of erosion caused by the dredging of surrounding coral reefs.

c) That the outer reefs of the Kepulauan Seribu showed relatively high coral cover and diversity values compared with reefs in the Bay of Jakarta -and that similar results were obtained for the diversity and abundnce of reef associated fish.

d) Analysis of coral cover and diversity results, indicated a close agreement between % coral cover defined by species intercept and 'life-forms' methods. The latter method, however, does not provide any index of species.

e) That the influence of human induced damage was clearly shown in the amount of flotsam recorded around islands, with those close to Jakarta being particularly affected by this waste.

f) That massive coral growth measurements and fluorescent banding patterns yielded no clear distinctions between the Bay of Jakarta and the Kepulauan Seribu since variability in these parameters was so considerable, yielding marked differences even within specimens collected at the same site.

Despite obvious human induced damage to coral reefs in the vicinity of Jakarta, the effects of natural disturbances to coral reefs were also clear to see during the workshop. During April 1983 many corals bleached (lost their zooxanthellae) at sites throughout the Kepulauan Seribu as a result of an increase in water temperatures on the reef flats. It is likely that the seawater warming effect was closely linked with documented El Nino events in the pacific Ocean at this time. At Pulau Pari, in the southern most Kepulauan Seribu, where the reef has been regularly monitored since 1979, there was considerable coral mortality both on the reef flat and to depths of 15m on the reef slope at certain locations. Coral cover at one site was reduced from 60% to less than 1% after the warming event. Recovery is now taking place and coral cover values of 5% were recorded at this site during the workshop, some two years after the bleaching episode. Such natural fluctuations in community structure are clearly important to bear in mind when considering man made damages to coral reefs.

The workshop emphasised not only the need for stricter control of man made interferences close to the capital (e.g. dredging restrictions, sewage treatment, pollution control measures) and indeed throughout the chain of outer islands; but also the importance of regular monitoring of long term changes on coral reefs and more careful analysis of parameters such as coral growth which have previously been hailed as indicators of environmental stress.

Participants comments, at the completion of the workshop, indicated that they had found the training both useful and stimulating. Indeed they were to be congratulated on their enthusiasm throughout the long hours of fieldwork (estimated as 550 man days in the Kepulauan Seribu). Specific recommendations which were voiced at the close of the workshop included the need for further training in statistical methods and the use of micro computers in data analysis and also a future workshop on aspects of coral reef management.

APPENDIX 1

Advisors and Participants in the first section of the workshop based at the Jepara field station, University of Diponegoro.

Advisors

Dr B.E. Brown
Department of Zoology
University of Newcastle upon Tyne
Newcastle upon Tyne NE1 7RU
UNITED KINGDOM

Dr J.R.E. Harger
UNESCO-ROSTSEA
Jl. Tamrin 14
Jakarta
INDONESIA

Dr T.P. Scoffin
Grant Institute of Geology
University of Edinburgh
West Mains Road
Edinburgh EH9 3JW
UNITED KINGDOM

Dr D.R. Stoddart
Department of Geography
University of Cambridge
Downing Place
Cambridge
UNITED KINGDOM

Participants

Mr Rizwain Abdurahman
Fac. Fisheries and Marine Science
Universiti Pertanian Malaysia
Serdang, Selangor
MALAYSIA

Mr M. Adrim
LON-LIPI
National Institute of Oceanology
Jl. Pasir Putih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Nr Sutrisno Anggoro
Fak. Peternakan Universitas Diponegoro
Jl. Hayam Wuruk 4A
Semarang
INDONESIA

Mr John Genolagani
Department of Fisheries
P.O. Box 320
University of Papua New Guinea
Waigani, N.C.D.
PAPUA NEW GUINEA

Mr Pranoto Hamidjojo
LON-LIPI
National Institute of Oceanology
Jl. Pasir Patih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Ms Sri Haryati
Fak. Peterkan Universitas Diponegoro
Jl. Hayam Wuruk 4A
Semarang
INDONESIA

Mr Ign. Boedi Hendrarto MSc
Fal. Peterkan Universitas Diponegoro
Jl. Hayam Wuruk 4A
Semarang
INDONESIA

Mr Malikusworo Hutomo
LON-LIPI
National Institute of Oceanology
Jl. Pasir Putih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Mr Abdullah Kamaludheen
Department of Public Works and Labour
Male
REPUBLIC OF THE MALDIVES

Mr Zhang Yuan Lin
South China Sea Institute of Oceanology
Academia Sinica 164
Xingang Xiroad
Guangshou
CHINA

Ms Anna Manuputty
LON-LIPI
National Institute of Oceanology
J. Pasir Putih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Ms Felicidad 'Ning' Matillano
Bureau of Fisheries and Aquatic Resources
Fisheries Research Division
Coral Reef Project
1184 Ben-Lor Blog
Quezon Avenue
Quezon City 3008
PHILIPPINES

Mr W. Moka MSc
Centre of Marine Resources Development
Hasanuddin University
INDONESIA

Ms Siti Nuraini
Marine Fisheries Institute
Jalan Krapu 12
Sunda Kelapa
Jakarta 1430
INDONESIA

Mr Otto Ongkosongo
LON-LIPI
National Institute of Oceanology
Jl. Pasi Putih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Mr Bambang Prasetyo
PPTMGB Lemigas
Jakarta
INDONESIA

Ms Sandra V. Rosales
Bureau of Fisheries and Aquatic Resources
Fisheries Research Division
Coral Reef Project
1184 Ben-Lor Blog
Quezon Avenue
Quezon City 3008
PHILIPPINES

Mr Dicky Sahetapy
Marine Bilogy Department
Fac. of Fisheris
Patimura University
INDONESIA

Ms Yusni Ichwan Siregar
Fisheries Department
Riau University
INDONESIA

Mr Pichai Sonchang
Bangsaen Institute of Marine Science
Srinakharinwirot University of Bangsaen
Chonburi
THAILAND

Mr Jung Chang Su
National Fisheries Research & Development Agency Nambang-dong
Young do-gu
Busan
SOUTH KOREA

Mr Suharsono
LON-LIPI
National Institute of Oceanology
Jl. Pasir Putih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Dr Sukarno
LON-LIPI
National Institute of Oceanology
Jl. Pasir Putih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Mr I. Nyoman Sutarna
LON-LIPI
National Institut of Oceanology
Jl. Pasir Putih 1, Ancol Timur
P.O. Box 580 DAK
Jakarta Utara 11001
INDONESIA

Mr Supriharyono
Universitas Diponegoro Marine Laboratory
Box 14
Jepara
INDONESIA

Dr Lachmuddin Sya'rani
Fisheries Department
Fac. of Animal Husbandry
Diponegoro University
Jl. Hayam Wuruk 4A
Semarang
INDONESIA

Mr E.F. Yusiaul
Medical Department
University of Diponegoro
Jl. Hayam Wuruk 4A
Semarang
INDONESIA

APPENDIX 2

Advisors and Participants in the second section of the workshop based in the Kepulauan Seribu.

(Addresses given only for those participants who did not take part in the first section of the workshop).

Advisors

Dr B.E. Brown

Dr J.R.E. Harger

Dr Don Kinsey
Australian Institute of Marine Science
PMB No. 3
Townsville M.C.
Queensland 4810
AUSTRALIA

Dr Hans Moll
RMNH Raamsteeg 2
P.O. Box 9517
RA 2300 Leiden
NETHERLANDS

Dr T.P. Scoffin

Dr D.R. Stoddart

Mr Lyn De Vantier
Australian Institute of Marine Science
PMB No 3
Townsville M.C.
Queensland 4810
AUSTRALIA

Dr Nick Willoughby
Department of Fisheries
University of Diponegoro
Jl. Hayam Wuruk 4A
Semarang
INDONESIA

Participants

Mr Ridzwan Abdurahman

Mr M. Adrim

Mr J. Genolagani

Mr M. Hutomo

Mr Zhang Yuan Lin

Ms Felicidad 'Ning' Matillano

Mr Otto Ongkosongo

Ms Sandra V. Rosales

Mr Pichai Sonchang

Mr Jung Chang Su

Mr Suharsono

Dr Sukarno

Mr I. Nyoman Sutarna

Mr Supriharyono

UNESCO REPORTS IN MARINE SCIENCE

No.		Year
37	Principles of Geological Mapping of Marine Sediments (with special reference to the African continental margin) Available in English and Russian	1986
38	Marine Sciences in CMEA countries Programme and results of co-operation Available in English and Russian	1986
39	Development of marine sciences in Arab Universities Meeting of Experts held at the Marine Science Station Aqaba, Jordan 1-5 December 1985 Available in Arabic, English, French	1986
40	Human induced damage to coral reefs Results of a regional Unesco (COMAR) workshop with advanced training Diponegoro University, Jepara and National Institute of Oceanology Jakarta, Indonesia May 1985 English only	1986

Title of numbers which are out of stock

No.		Year
3	Benthic ecology and sedimentation of the south Atlantic continental platform Report of the seminar organized by Unesco in Montevideo, Uruguay, 9-12 May 1978	1979
7	Coastal ecosystems of the Southern Mediterranean; lagoons, deltas and salt marshes, Report of a meeting of experts, Tunis, 25-27 September 1978	1979
11	Programa de Plancton para el Pacífico Oriental Informe final del Seminario-Taller realizado en el Instituto del Mar del Perú, El Callao, Perú, 8-11 de septiembre de 1980	1981
12	Geología y geoquímica del margen continental del Atlántico Sudoccidental Informe final del Taller de Trabajo organizado por la Unesco en Montevideo Uruguay, 2-4 de diciembre de 1980	1981
13	Seminario Latinoamericano sobre Enseñanza de la Oceanografía Informe final del Seminario organizado por la Unesco en São Paulo, Brasil, 17-20 de noviembre de 1978	1981
17	The coastal ecosystems of West Africa: coastal lagoons, estuaries and mangroves A workshop report, Dakar, 11-15 June 1979	1981