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Singapore's
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Strategies for
Management

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**SINGAPORE'S URBAN COASTAL AREA:
STRATEGIES FOR MANAGEMENT**

Chia Lin Sien

1992



IGLARM



**Association of Southeast Asian Nations/United States
Coastal Resources Management Project
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Singapore's Urban Coastal Area: Strategies for Management

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LIST OF ACRONYMS AND ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
bpd	barrels per day
CAM	coastal area management
CBD	Central Business District
CIAS	Changi International Air Services
CRM	coastal resources management
CRMP	Coastal Resources Management Project
CZM	coastal zone management
DOS	Department of Statistics
dwt	deadweight ton
ft	freight ton
FTZ	Free Trade Zone
GDP	gross domestic product
grt	gross registered ton
HDB	Housing and Development Board
ICLARM	International Center for Living Aquatic Resources Management
JTC	Jurong Town Corporation
LNG	liquefied natural gas
MAS	Marine Aquaculture Section
MNS	Malayan Nature Society
MOE	Ministry of the Environment
MOND	Ministry of National Development
NIE	newly industrializing economy
NPB	National Parks Board
NSTB	National Science and Technology Board
NUS	National University of Singapore
OBS	Outward Bound School
OSTC	Oil and Sludge Treatment Centre
P.	Pulau
PA	People's Association
PCS	Petrochemical Corporation of Singapore Pte. Ltd.
PPD	Primary Production Department
PRD	Parks and Recreation Department
PSA	Port of Singapore Authority
RSYC	Republic of Singapore Yacht Club
SAF	Singapore Armed Forces
SATS	Singapore Air Transport Services
SBM	single buoy mooring
SDC	Sentosa Development Corporation
SEAFDEC	Southeast Asian Fisheries Development Centre
SIB	Singapore Institute of Biology
SOBS	Singapore Outward Bound School
SSLC	Singapore Seaports Liaison Committee
STPB	Singapore Tourist Promotion Board

List of Acronyms and Abbreviations

SUF	Singapore Underwater Federation
TEU	twenty-foot equivalent unit
T.P.	Terumbu Pempang
ULCC	ultra large crude carrier
UNEP	United Nations Environment Programme
URA	Urban Redevelopment Authority
USAID	United States Agency for International Development
WTC	World Trade Centre

PREFACE

The Association of Southeast Asian Nations/United States Coastal Resources Management Project (ASEAN/US CRMP Singapore component) began in late 1986 under the auspices of the then Science Council of Singapore and now the National Science and Technology Board (NSTB). The participating agencies were the Primary Production Department (PPD) of the Ministry of National Development (MOND) and the National University of Singapore (NUS). Officially titled as ASEAN/US Cooperative Program on Marine Science: Coastal Resources Management Project, it involved all six member-countries of ASEAN, was funded by the United States Agency for International Development (USAID) and coordinated by the Coastal Area Management (CAM) Program of the International Center for Living Aquatic Resources Management (ICLARM).

The pilot site used for this project was the coastal area of the Southern Islands including the waters, offshore islands and coastal land of the main island of Singapore. The area chosen is highly complex in terms of its physical configuration, characteristics, uses and activities. The highly urbanized and intensely developed coastal land on the main island bounding the northern portion of the area added to the complexity. Other coastal areas along Johor Strait and the southeast coast, known simply as the East Coast, also presented interesting and challenging management problems.

Singapore's coastal area is characterized by two main features. First, while physical changes were already taking place since the founding of Singapore in 1819, its development has been rapid and intensive over the last three decades with new uses and activities supplanting the old ones. Extensive foreshore reclamations on both the main island as well as on many of the offshore islands have drastically changed its ecological conditions and patterns of use. Second, the coastal area's resources, land and seaspace have been put under highly intensive uses principally for shipping and the operation of seaports, the different industries and recreation-cum-tourism over the last two decades. These are followed by such activities as fishing and aquaculture, transportation other than shipping, commercial developments partly for recreation and tourism, defense and population settlement. In addition, the coastal area is taken up by airport services, telecommunications networks and religious/cultural practices.

Thus far, the changes from the use of the coastal resources in Singapore have tended to favor meeting developmental needs economically, socially and otherwise rather than satisfying environmental requirements to conserve these resources. For a newly emerging nation, this is quite appropriate and necessary, but not for Singapore which has already attained the status of a developed nation and, from the 1980s, a heightened sense of environmental consciousness. Thus, from the rapid changes and the high intensity of usage of these coastal resources and space, there have emerged incompatible and conflicting situations that need to be redressed. Among the major areas of

Preface

conflict are those generated by pollution due to the discharge of solid and liquid wastes into the coastal environment.

The project set out to examine the issues and problems relating to the pattern and nature of coastal area uses. It also sought to develop a management strategy (rather than a plan) which promotes multisectoral and integrated coastal resources uses at their peak efficiency to maximize the benefits to be derived; identifies and prioritizes management issues; and recommends appropriate remedial actions. When formulated, this management strategy was presented at the Second National Workshop on Urban Coastal Area Management held 9-10 November 1989 to seek the endorsement of representatives of Singapore's government agencies and private organizations as well as researchers who attended the workshop. It is hoped that the comments and suggestions made then would help to produce a final management strategy which can be used by the appropriate agencies.

This document was to have been finalized for publication in the first quarter of 1991 but for two major new developments. The first was the submission (and subsequent publication) to the Singapore government of the *Master Plan for the Conservation of Nature in Singapore* by the Malayan Nature Society (MNS) (recently separately constituted as the Singapore Nature Society) in late 1990. A related proposal for the conservation of coral reefs in Singapore was likewise submitted in July 1991 by the Republic of Singapore Yacht Club (RSYC), the Singapore Underwater Federation (SUF) and the Singapore Institute of Biology (SIB). The latter proposal was based on the results of these organizations' three-year Reef Survey and Conservation Project which was supported by the Singapore Seasports Liaison Committee (SSLC). The second major development was the presentation of the revised Long-range Comprehensive Concept Plan during the City Trans Asia '91 Exhibition organized by MOND on 14-17 September 1991. This plan contains vital details of future developments affecting the country's coastal area which have important implications on the management strategy envisaged in this document. It was, therefore, necessary to undertake considerable revisions to accommodate new information from the above developments. In addition, attempts were also made to integrate the essential findings of two other major tasks insofar as they are able to provide the essential background toward an understanding of coastal resources and thus contribute to their management. The tasks are (1) marine conservation and pollution control and (2) the role of artificial reefs in living resources enrichment.

Chia Lin Sien
National University of Singapore
18 February 1992

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FOREWORD

The coastal waters of Southeast Asian countries have some of the world's richest ecosystems characterized by extensive coral reefs and dense mangrove forests. Blessed with warm tropical climate and high rainfall, these waters are further enriched with nutrients from the land which enable them to support a wide diversity of marine life. Because economic benefits could be derived from them, the coastal zones in these countries teem with human settlements. Over 70% of the population in the region lives in coastal areas where resources have been heavily exploited. This situation became apparent between the 1960s and 1970s when socioeconomic pressures increased. Large-scale destruction of the region's valuable resources has caused serious degradation of the environment, thus affecting the economic life of the coastal inhabitants. This lamentable situation is mainly the result of ineffective or poor management of the coastal resources.

Coastal resources are valuable assets that should be utilized on a sustainable basis. Unisectoral overuse of some resources has caused grave problems. Indiscriminate logging and mining in upland areas might have brought large economic benefits to companies undertaking these activities and, to a certain extent, increased government revenues, but could prove detrimental to lowland activities such as fisheries, aquaculture and coastal tourism-dependent industries. Similarly, unregulated fishing effort and the use of destructive fishing methods, such as mechanized push-nets and dynamiting, have seriously destroyed fish habitats and reduced fish stocks. Indiscriminate cutting of mangroves for aquaculture, fuel wood, timber and the like has brought temporary gains in fish production, fuel wood and time supply but losses in nursery areas of commercially important fish and shrimp, coastal erosion and land accretion.

The coastal zones of most nations in ASEAN are subjected to increasing population and economic pressures manifested by a variety of coastal activities, notably, fishing, coastal aquaculture, waste disposal, salt-making, tin mining, oil drilling, tanker traffic, construction and industrialization. This situation is aggravated by the expanding economic activities attempting to uplift the standard of living of coastal people, the majority of whom live below the official poverty line.

Some ASEAN nations have formulated regulatory measures for their CRM such as the issuance of permits for fishing, logging, mangrove harvesting, etc. However, most of these measures have not proven effective due partly to enforcement failure and largely to lack of support for the communities concerned.

Experiences in CRM in developed nations suggest the need for an integrated, interdisciplinary and multisectoral approach in developing management plans that will provide a course of action usable for the daily management of the coastal areas.

Foreword

The ASEAN/US CRMP arose from the existing CRM problems. Its goal is to increase existing capabilities within ASEAN nations for developing and implementing CRM strategies. The project, which is funded by USAID and executed by ICLARM in cooperation with ASEAN institutions, attempts to attain its goals through these activities:

- analyzing, documenting and disseminating information on trends in coastal resources development;
- increasing awareness of the importance of CRM policies and identifying, and where possible, strengthening existing management capabilities;
- providing technical solutions to coastal resources use conflicts; and
- promoting institutional arrangements that bring multisectoral planning to coastal resources development.

In addition to implementing training and information dissemination programs, CRMP also attempts to develop site-specific CRM plans to formulate integrated strategies that could be implemented in the prevailing conditions in each nation.

As the title suggests, *Singapore's Urban Coastal Area: Strategies for Management* directs the discussion to issues relating to the environmental condition prevailing in Singapore, specifically those affecting coastal resources uses in an urban setting. There are likewise issues affecting the implementation of management goals and policies, the development of appropriate legislation and the need for further study.

While this book is addressed to policy- and decisionmakers, researchers and the environmentally alert will find valuable information in the processes involved in the formulation and implementation of a country's coastal area management plan.

Chua Thia-Eng
Project Coordinator
ASEAN/US CRMP and
Director, Coastal Area
Management Program, ICLARM

CHAPTER 1

INTRODUCTION

GENERAL BACKGROUND

Singapore has developed very rapidly economically and socially from the beginning of the 1960s and since becoming a sovereign nation on 9 August 1965. The country's population was just over 3 million in 1990. It enjoys one of the highest standards of living in Asia and has even caught up with some of Europe's developed nations in terms of per capita income which, in 1990, stood at S\$18,437 (= US\$10,172) (DOS 1990).

The city-state has benefited from the excellent social, economic and physical planning which has been largely responsible for the rapid transformation of the country (Chia 1981). Of its total area of 633 km² (in 1990), nearly half the territory has been built on. The country has reached a stage where the major infrastructural elements such as the road system, air and seaports, and communications are already in place and at an advanced stage of development, although there will always be new major physical developments to be undertaken which will likely affect the coastal zone. In effect, the coast has become the new frontier for change. However, while much has been achieved in planning the physical development over land, the use of sea-space has only in recent years been effectively planned.

The coast has become the new frontier for change--meeting urgent developmental needs, on the one hand, and fulfilling ecological imperatives, on the other.

The main objective of this study is to examine how the coastal area of Singapore can be more efficiently utilized, taking into account the interconnected, and often conflicting, goals of meeting urgent developmental needs, on the one hand, and fulfilling ecological imperatives, on the other. By and large, up till the present, developmental requirements for the rapidly growing economy have been satisfied while official and public attention has turned increasingly toward greater awareness and more action to realize environmental conservation and enhancement for the benefit of the nation as a whole.

In the 1980s, this has been very much in keeping with the country's aspiration toward attaining the status of a modern and developed nation with a conducive and gracious living environment for its population. As Mr. Goh Chee Wee, Chairman of the Government Parliamentary Committee for the Environment, has indicated, the nation looks forward to new and exciting developments in the 1990s in its coastal area which will see the greater utilization of the coastal resources and improvement of the coastal and marine environments, enabling the population to benefit and enjoy a higher quality of life (Goh 1991).

**ENVIRONMENTAL
CONDITION**

Singapore has an equatorial climate with a mean temperature of 26°C and an annual range of 2°C. Rainfall is high, ranging from under 2,000 mm to over 2,600 mm/year across the country with a relatively wet season around the end of the year. There is no distinct dry season. The island-nation is strongly monsoonal, being alternatively under the influence of the northeast monsoon (December to March) and the southwest monsoon (May to September) with two intermonsoon periods separating them. There are important year-to-year variations of the main weather elements as there are observed long-term climatic variations that have important consequences on the supply of potable water to meet the rising demand (Chia and Foong 1991). Along the coast, the land and sea breezes, a characteristic feature of coastal areas, are not well developed in Singapore although good strong landward breezes along the southeastern coast (hereinafter referred to as East Coast) are clearly noticeable and appreciated.

Singapore's history of erosion and sea level rise at the end of the last Ice Age some 10,000 years ago have brought about the present configuration of the coastline and general topography of the islands and seabed of the surrounding waters (Chou and Chia 1991; Thomas 1991). The excellent natural harbor is the product of the drowned coastline, giving the water its good depth and the coastline its sheltered position. The strong daily tidal flux of water keeps siltation to a minimum. The main island has an undulating topography with more than half of the land area below 30 m. The low-lying areas, especially the urban center at the mouth of the Singapore and Kallang Rivers, are subjected to floods during periods of heavy rainfall which coincides with the high tide. Most parts of the shoreline, including many of the offshore islands, have been highly modified as a result of land reclamations.

Singapore has undergone relative subsidence which created the many small islands. The deepest waters lie to the southeast of the main island. The coastal regime is characterized by a low-energy environment due to the weak wind conditions and the sheltering effect of the surrounding islands and Peninsular Malaysia which surrounds the entire northern portion of the coast. The tidal regime is semidiurnal with a mean tidal range of 2.2 m and a spring maximum of 3.0 m. There is one strong east-going tidal stream lasting for over 15 hours and two west-going streams diurnally. Monsoon currents are superimposed on tidal currents. The overall pattern shows a strong westerly water flow to the south of the main island of Singapore turning northward into Malacca Strait. The presence of the Johor causeway cuts Johor Strait in two, immobilizing water movements. Another strong influence on the movement and characteristics of the water in the strait is the discharge of Johor and other rivers into Peninsular Malaysia.

**SOCIAL AND ECONOMIC
SETTINGS**

Singapore experienced an almost continuous economic growth since the beginning of the 1960s. This was due to a combination of sound development planning, effective execution of programs and favorable external trading

Chapter 1. *Introduction*

conditions, earning for the nation the status of a "newly industrializing economy" (NIE) and propelling it to the status of a developed nation. Details of the country's economic achievements have been given in Chia et al. (1988). The following paragraphs discuss only aspects that bear on the development of the coastal area of Singapore.

Preliminary estimates of the 1990 census indicated that Singapore has a population of over 3 million and a density of 4,740/km², one of the highest in the world. Since the 1970s, the population has reached a level lower than the replacement rate as a result of the urbanization process and a government policy that deliberately controls population growth. Annual population rates fell continually from a high of over 4% in the late 1950s to a minimum of 1% in 1986 before a reversal registered a rate of 1.7% in 1990 (DOS 1990). The country has a labor force of 1.52 million and a low unemployment rate of 1.3%, but it has been experiencing a shortage of labor for some time. There are well over 100,000 unskilled and semiskilled foreign workers to fill jobs in construction, shipbuilding and repairing, and other industrial jobs.

Another aspect of the population has been its massive spatial redistribution as a result partly of the natural process of urban expansion and change and partly of the highly successful government low-cost public housing program now accommodating over 85% of the population living in high-rise apartments. Large self-contained new towns complete with a wide range of private and public services and facilities house 200,000 or more residents. These new towns have been established outside the central urban area since the 1970s, thus enabling the government to relocate large numbers of residents from the Central Area and to redevelop and transform large portions of it for more intensive commercial and civic uses.

The dynamic industrialization program which was a major feature of the first national development plan (1961-1964) was spearheaded by the development of the Jurong Industrial Estate (subsequently renamed Jurong Town) on the southwestern coastal area of the main island. Subsequently, other industrial estates were developed on the coast with the larger estates, such as Jurong and Sembawang, taking advantage of waterfront land for the convenient movement of their cargoes internationally.

The emergence of tourism from the late 1960s as an important contributor to the country's economic growth has been recognized, as evidenced by the heavy investments in tourism facilities to absorb the increase in the flow of tourists which numbered 5.3 million in 1990 compared to half that number in 1980 (DOS 1990). The development of these tourism facilities ties in with the increased demand for recreation by a population that is fast becoming affluent, requiring more land for open spaces. An important segment of these leisure facilities is located within the coastal area, as in the case of those found on Sentosa and the adjacent islands.

Singapore's gross domestic product (GDP) has doubled since 1980 to reach nearly \$57 billion (at the 1985 market price) in 1990. The economy has become more diversified except for the negligible primary sector which accounts for only half a percent of the GDP. The manufacturing, commerce and service sectors have grown to 29.1, 17.3 and 42.9%, respectively, in 1990 (DOS 1990). These sectors are now more resilient and better able to withstand external shocks as demonstrated by their quick recovery from the oil shock and the worldwide economic slowdown in 1973 and 1974 and in the early 1980s.

The constraints of development are derived from the country's small size and shortage of both physical and human resources. The strategies adopted in the 1970s have been to move away from the labor- and land-intensive industries, focusing on the high-value added, high-technology and capital-intensive activities such as sophisticated electronics, chemical and pharmaceutical industries, banking, insurance and professional services. To overcome the basic problems, the new economic policy will take advantage of fresh opportunities and create new niches to ensure future growth (MOTI 1986). It will give emphasis to such activities as skills development, greater automation and computerization, information technology, and research and development.

The eventual size of the population has been placed at around 4 million by 2030 A.D. and beyond (Olszewski and Chia 1991). But the limits to its growth are determined by the lack of land space and water supply. The problem of insufficient land space has been tackled by maximizing the use of available land as well as acquiring new land from foreshore areas and around offshore islands. The technology used for reclamation could reach the 15-m depth if the demand for land justifies it. There is intensive use of land for commercial developments within the Central Business District (CBD) and for those planned for industrial estates. In addition, there is a need for land for housing and other essential developments.

Increasingly, attention will be turned toward the use of all available space, whether on land or in the sea. Physical planning has thus far been concerned primarily with the efficient use of the latter, while the responsibility for utilizing seaspace has been given over to the Port of Singapore Authority (PSA) since shipping and port uses have become the dominant forms of coastal area usage. As earlier noted, the demand for marine-based recreation and tourism has risen over the years as has the awareness of marine conservation to enhance the country's environmental quality (Chia and Chou 1991; Wong 1991). However, those agencies responsible for achieving the country's developmental goals, which are unisectoral in nature, may not yet have been able to realize that there are likely to be new opportunities and challenges in the way that seaspace is being utilized.

CHAPTER 2

RATIONALE FOR COASTAL AREA MANAGEMENT IN SINGAPORE

This chapter attempts to lay down the principles employed in CAM, including its ecological basis. For Singapore, with its limited land and seaspace, it is essential to first consider the extent of the coastal area and the nature of the coastal resources. This chapter also discusses the process of formulating and implementing the management plans.

PRINCIPLES OF COASTAL AREA MANAGEMENT

The principles governing the management of coastal or marine resources are discussed in detail by Odum (1976); Clark (1977); Maragos et al. (1983a); Snedaker and Getter (1985); Peet (1988); and others. There are available manuals for the management of specific resources such as estuaries and wetlands (AMSA 1977), offshore oil and gas development (Gilbert 1982), mangroves (Hamilton and Snedaker 1984), as well as for specific aspects of coastal zone management (CZM), e.g., institutional arrangements (Sorensen et al. 1984).

Also, there are a number of regional (province or state) and national studies such as those for Malaysia and ASEAN states (see various papers in Soysa et al. 1982), and CZM plans for Sri Lanka (Amarasinghe et al. 1987; Lowry and Wickremeratne 1988), Hawaii (State of Hawaii-DPED 1982; Lowry 1989) and Thailand (Kiravanich and Bunpapong 1989).

As part of ASEAN/US CRMP, the participating countries have also been preparing management plans for their respective pilot sites. The enactment of the US Coastal Zone Management Act of 1972 provides an interesting example of using legislation to control development in the coastal zone; albeit it refers to the experience of an advanced temperate-latitude country.

CAM has also been the subject of many conferences, seminars and workshops in the Southeast Asian region (see, for example, Valencia 1981; Soysa et al. 1982; Magoon et al. 1987, 1989; and Chua and Pauly 1989). Finally, there is a growing body of case studies found in the proceedings of conferences, journals and edited volumes of collected papers (see, for example, Clark 1985). While there is no lack of reference materials and case studies to serve as guidelines for CAM planning, the distinctive set of biophysical, political,

The distinctive set of biophysical, political, social and economic conditions for each site and situation constitutes the unique task of developing management policies, instruments and strategies.

**ECOLOGICAL BASIS
FOR COASTAL AREA
MANAGEMENT**

In Singapore, the original natural environment has been modified beyond recognition although the basic natural processes continue to operate.

social and economic conditions for each site and situation constitutes the unique task of developing management policies, instruments and strategies which take into account the developmental, ecological, legal, administrative, available human and technical resources as well as other factors.

CAM recognizes that an understanding of the ecological processes and the characteristics of the natural habitats found in the local context is the starting point. The coastal zone is highly productive of biomass and organisms. The system supports a number of distinct ecological habitats—estuaries, lagoons, beaches, seagrass beds, coral reefs, and mangrove and nipa swamps. The climate, geology, soils and the evolutionary history of a particular area would produce a unique assemblage of habitats. Human occupation and interference of the physical environment would alter and cause changes, which may be subtle and superficial but may sometimes be massive and irreversible to the natural system.

In Singapore, the original natural environment has been modified beyond recognition although the basic natural processes continue to operate (Chia et al. 1986). However, given sufficient time and careful management to protect and conserve habitats such as coral reefs, seagrass beds and beaches, these will regenerate themselves to varying degrees. For example, it would take some 5 to 50 years for coral reefs to reestablish themselves, depending on the prevailing conditions.

Moreover, the health of each of these habitats is in many ways dependent on the adjacent habitats. For example, coral reefs found around the islands and along the shores of the larger land masses rely on the supply of nutrients from mangroves and other terrestrial sources and, in turn, provide nutrients essential for the survival of the associated and adjacent seagrass beds and marine life. Also, changes in the condition of upland watersheds (e.g., land clearance) alter the composition of the material and the quality, including temperature, salinity and turbidity of the water discharged by rivers, thus creating impacts on coastal habitats.

The coastal area also harbors a very large assemblage of living organisms and materials which can be utilized by man. These resources can be categorized as renewable and nonrenewable. Renewable resources, such as fish and sago palm, are sources of food and provide many useful materials for building and for making implements, ornaments and other products. Nonrenewable resources include sand and granite and, in other coastal states, may include highly valuable resources such as minerals and hydrocarbon deposits. In Singapore, these natural resources are insignificant in monetary terms. However, their importance is derived from the manner of their exploitation, e.g., from the environmental and educational points of view.

The abundance of the renewable resources from which food and other useful materials can be obtained depends very much on the healthy state of the natural habitats. Within the region, fish from coral reefs account for 10-30% (McManus 1988; Gomez 1989). The coral reefs of Singapore are rich in biodiversity (Lee et al. 1991). Seagrass beds support a myriad of living organisms and are therefore vital for the survival of commercially important fish. Destruction, damage and alteration of their ecological conditions will adversely affect these habitats and inevitably lead to the diminished abundance of these renewable resources and reduced productivity of the system. Lee et al. (1991) also warned that, already, the deeper zones of the local reefs have been devastated while the shallower zones which continue to support an amazingly high species diversity and coral growth are under serious threat of extinction if no concerted action is taken to preserve them.

The extraction of coastal sand, granite and tin deposits is generally accompanied by the scarring of the landscape, damage to the surrounding soils and vegetation, and pollution of the water courses and marine environment (Wong 1969). These activities may also degrade the scenic quality, leading to the loss of possible alternative uses of the sites. Rehabilitation of these disturbed sites can be very costly, as in the removal of the topsoil and sand along parts of the coast of Pulau Ubin. It also raises questions on what appropriate legislation and technical support are needed to control environmental pollution and who should pay for the cost of restoring the environment.

SPACE AND LOCATION AS RESOURCES

It is now important for planners to expand the planning horizon beyond the coastline and maximize the use of the resources with the unique qualities of the land-sea interface.

In the context of Singapore, the concept of a "resource" should not be restricted to what has been discussed above but should be extended to include space, location and quality of site. The country's land space has become a critical resource and constitutes a major factor in considering the limits to the growth of the nation. A study of the geography of Singapore examines several responses of people to the severe constraint of limited space. One response has been to maximize the value of space (through detailed physical planning) to ensure that it is used effectively under rapidly changing conditions. Another response has been to increase land area through foreshore reclamation—a practice which is adopted by not only small states but also large and what appears to be land-abundant countries. It is now important for planners to expand the planning horizon beyond the coastline to include the marine space encompassing all the territorial waters of Singapore. Coastal area planning should seek to integrate the elements of both land and water in order to maximize the use of the resources with the unique qualities of the land-sea interface.

In many ways, seaspace is regarded as a liability since it constitutes a barrier to movement. Getting to an offshore island requires a change in the mode of transport which is, by its very nature, slow, and in some cases, hazardous

compared with movement over land. The usual way to overcome the problem of separation is to use a variety of water craft. Marine transport has a cost advantage over other major forms of transport for longer distances and for the carriage of large quantities of bulky homogeneous materials. But to overcome the need to change transport modes and still link separate land masses will require the building of bridges, causeways and undersea tunnels. Technology is readily available for the construction of such structures and facilities, the main constraint being the cost of construction and the benefits to be accrued from them.

Foreshore reclamation, which has been actively pursued to gain more land from the sea, pushes the land mass seawards, thereby altering the relationship between the land and the coastal waters. It drastically changes the physical and biological characteristics of the coast and imposes limits to how much land can be gained, considering the increasing cost of reclaiming land in deeper waters. Often, reclamation destabilizes the coastline and, to protect the shore, costly structures have to be erected. For a highly urbanized coastal area where there is a high demand for land for commercial, industrial and other purposes, the cost of reclamation can easily be justified for space-short Singapore. However, a gain in land area means an equal amount of loss of seaspace vital for marine uses (Lim 1991) since it has not been usual for such projects to consider the costs due to the damage to and loss of biological productivity, recreational amenity and scenic quality.

On a global and regional scale, the geographical configuration of its land masses has endowed Singapore with a strategic location for marine (and air) transport. Recognition of this significance by Sir Stamford Raffles led him to develop Singapore into an entrepôt and trading post to control the trade gateways of the surrounding region and the Far East. Today, the basic system has not changed. The country became the region's transport hub and trading center with a worldwide network of air and shipping services, attesting to the crucial importance of its location.

There is a considerable variation in the physical and chemical characteristics of the water and the configuration of the seabed underlying the seaspace of the country (Chou and Chia 1991). The differences arise from such factors as the shape of the shoreline, depth of water, distance from land masses and availability of fresh water. One major asset are the deep nearshore waters sheltered from strong wave action by the offshore islands, thereby, providing Singapore with an excellent natural harbor. Along other sectors of the coast, the shallow nearshore waters have made it feasible to reclaim large areas from the sea to provide land for much needed development. These variations are important in determining these waters' optimal use, whether as anchorages, shipping lanes, aquaculture sites, or seaport or conservation areas. The abundance of marine life on the seabed as well as the other qualities of the site are important considerations.

As for the coastal land, there are differences underlying its geology, geometry of shoreline, slope of land, type of vegetation and fauna, and scenic quality. Land use planners take advantage of these variations on the main island by setting aside suitable land for seaports and industrial development and by allocating elevated coastal land for open spaces and recreational uses. In the development of structures such as piers, buildings, airport runways as well as parks, details of the site's characteristics and subsoil conditions are important. However, optimal use of valuable coastal lands, including the off-shore islands, has not been achieved in the push for urgent development in the early years following the nation's independence. Thus, adjustments and reviews of the earlier plans should be made, taking into account the characteristics of the coastal area.

THE NATURE OF COASTAL RESOURCES USES

The benefits from the utilization of Singapore's coastal area have changed rapidly for the past three decades (Chia 1982; 1985). To a large extent, these changes have come about mainly as a result of the urgent demand for space for economic development. Traditional use forms, such as fisheries and human settlements have had to give way to more intensive uses that provide much higher returns. The new developments, involving extensive foreshore reclamations and subsequent use of space for industries, port expansion and others, are carried out under the responsibility of powerful national agencies and guided by the Master Plan and the Long-range Comprehensive Concept Plan (hereinafter referred to as Concept Plan) (Olszewski and Chia 1991). Available seaspace has been turned into a patchwork of anchorages and fairways for navigation. Until a decade ago, these new uses have given little regard to environmental protection and the possibility of accommodating the earlier uses. But current PSA practices allow their coexistence with other users (Lim 1991).

Historically, capture fisheries by the local population is an important activity but, for reasons other than the loss of local fishing grounds, this and other sectors have progressively declined since the 1950s compared to other sectors. The emphasis on agriculture has also shifted away from labor- and land-intensive types of activities to those employing high-technology methods of food production. The Singapore River's mouth, the nearby "inner roads" (now reclaimed) and Keppel Harbour have been the scenes of intense activity for shipping and port operations (Chia 1989). Since the early 1960s, three other sea terminals--Pasir Panjang, Sembawang and Jurong--have been added while Keppel Terminal (incorporating the Telok Ayer Basin) has been continually upgraded and transformed to augment the modern container port, the Tanjong Pagar Container Terminal. These changes reflect the phenomenal increase in shipping activities catered by a continually expanding and efficient port system. More changes are anticipated further with the rapid growth in the volume of cargo throughputs. To date, an announcement has been made to relocate the Tanjong Pagar Container Terminal to make way for the expansion of the downtown area of Singapore (*Straits Times*, 18 May 1991 issue).

Many changes have also taken place along the waterfront of the main and the offshore islands. Changes in the former have been due largely to the reclamation of foreshore lands which has effectively removed the previous waterfront uses (residential, institutional, fishing and aquaculture) to give way to mainly recreational, industrial and port uses (Yong et al. 1991). Changes have also enlarged the offshore islands and merged these with other islands to render them suitable for industrial and special uses. Other islands, notably Sentosa, have been reserved for tourist/recreational developments. These changes have led to the removal of populations from all the islands, except for Pulau (P.) Ubin and P. Seking. But even in these islands, which have been earmarked for other developments, the population is moribund (Chia and Khan 1987). As indicated earlier, changes in coastal uses have necessarily resulted in conflicts among users.

The revised Concept Plan, which was publicly disclosed in August 1991, proposes to use waterfront land and seaspace much more intensively than they have been previously. Waterfront housing, resorts, marinas, a variety of seasport and leisure activities are envisaged for the future development of the coastal area of Singapore (URA 1991). Also, the Concept Plan has allowed housing, be it public or private, on waterfront land hitherto denied except for some locations along the north shore of the main island. In the past, the government has not adequately responded to meet the demand of Singaporeans to release suitable waterfront lands for seasports (Lee 1991).

There are three main categories of coastal uses. The first category involves the utilization of either renewable or nonrenewable resources, e.g., fishing, marine aquaculture, and collecting corals and ornamental fish (Ho 1992). The second needs a waterfront location for purposes such as the handling of bulk cargoes from land to sea and vice versa which are essential for trade and industries requiring the importation of large amounts of raw materials (e.g., sawmills, feedmills and cement factories). The third takes place because of some specific qualities of the coastal area, such as sandy beaches, good scenery, clean seawater, sheltered or open, shallow or deep waters, among others. Details of current coastal uses and activities are discussed in a subsequent section of this book.

**COASTAL AREA
MANAGEMENT PLAN
FORMULATION**

The approach adopted in formulating Singapore's CAM Plan is based on the guidelines given in Chua and Agulto (1987). In a situation of intense competition for the use of these limited coastal resources, the plan enables policy-makers to wisely use the resources on an integrated and sustainable basis. Adverse consequences arising from resources uses are to be minimized by selecting from among a range of management options which attempts to regulate the type and manner of exploitation, as well as seek ways to restore or rehabilitate damaged or depleted resources. Moreover, the set of measures to be selected should be those available within the political and socioeconomic context of the situation as it is argued that the successful implementation

The approach adopted in formulating Singapore's CAM Plan enables policymakers to wisely use the resources on an integrated and sustainable basis.

of any management scheme requires a multisectoral approach reinforced by the strong support and commitment of the local population and the government. Thus, the outcome of public pressure at any one time may influence public opinion which may at a later stage cause adjustments to the measures that will be adopted. In a democratic system, it is possible to envisage in the scheme an interactive relationship among policymaking and implementing agencies, the users and the private sector.

Clearly, planning CAM takes into account several processes. First, it is necessary to possess a thorough understanding of the existing patterns of use, the underlying factors, and the evolution and interrelationship of current policies and actions taken for each of the diverse uses. Often, the measures to be implemented may not be formally legislated but rather take the form of administrative requirements, guidelines and directives. Second, it is necessary to be familiar with the various government agencies responsible for CAM as well as the consultative coordinating committees of two or more agencies to effect the smooth implementation of the measures.

For example, the project undertaken to clean up the Singapore and Kallang Rivers involved the cooperation of many government agencies although the overall responsibility came under the Ministry of the Environment (MOE) (Khoo 1989). As part of the project, two national workshops were organized to facilitate the exchange of information, views and ideas among relevant government and private agencies as well as other resource persons. The first workshop, on 28 October 1986, was small-scale and was intended to establish contacts between the research team and key government agencies, while the second workshop, held on 9-10 November 1989, was broader in scope and participation. In these workshops, the interactive process was incorporated into the planning process. Similarly, field observations often provide opportunities to understand the details of these processes.

COASTAL AREA MANAGEMENT PLAN IMPLEMENTATION

Implementation of the CAM plan requires the following tasks:

- integration into the local and national physical development plans;
- development of management strategies;
- enforcement of regulations;
- funding;
- refinement of the plan (feedback);
- training of management personnel; and
- public education.

Making the Singapore CAM plan requires that it is integrated with national land use planning schemes as well as the detailed development plans of various public agencies managing coastal resources. However, for various reasons, it may not be possible to be privy to the details of the latter. Nevertheless, efforts must be made to take into account these agencies' current set

It is argued that the successful implementation of any management scheme requires a multisectoral approach reinforced by the strong support and commitment of the local population and the government.

of policies, strategies, structure and program of activities to ensure the adoption and implementation in part or as a whole of the proposed plan. Since the process is reiterative, substantial modifications may have to be made on the original proposed plan. In the implementation of the policies, developing instruments such as laws and administrative guidelines ensures that there are sufficient management and technical capabilities to bring about effective compliance.

Unless the strategies adopted are in line with existing management practices, new or expanded management schemes will require additional funds to carry out and sustain them. Similarly, it is necessary to provide funds and development programs to train management personnel. In this regard, ASEAN/US CRMP provides opportunities for training and familiarization, while the CAM plan itself undergoes periodic revisions and refinement as often as when new technical information becomes available and as changes from new administrative arrangements are made. Finally, overall planning strategies require not only policymakers to promote the greater awareness of these changes but also the public through the mass media and the educational system. Thus, the CAM Program under ICLARM continues to develop suitable materials for this purpose.

This document falls short of actually proposing a comprehensive CAM plan for Singapore basically because it cannot be undertaken outside of the national planning agency and without the direct involvement of the various key development agencies concerned with the use and control of the coastal area. Also, the revised Concept Plan, which provides the guidelines for the nation's physical development, has just been finalized and released in September 1991, leaving very little time for these agencies to review it (the plan) and for the author to write about it. It will take some time before the various concerned development agencies work out the plan's full implications for each of them. Nevertheless, it is hoped that the findings of this plan will provide useful inputs in developing a comprehensive national coastal area strategic plan. Details touching on aspects of the coastal area will be discussed in a subsequent section of this document.

CHAPTER 3

COASTAL RESOURCES

Clearly, decisionmakers will have to consider whether the benefits to be derived from the further destruction of Singapore's coastal resources, which appears to be necessary as a result of development, truly outweigh the benefits to be had from offering them even greater protection.

As an essential step in developing a CAM plan, Chapters 3 and 4 were intended to provide a survey of the coastal resources and their utilization. But since this has to a large extent already been achieved in Chia et al. (1988), the material presented here will only highlight and, wherever necessary, update the information contained therein. Other publications on the coastal resources of Singapore are readily available (Chia et al. 1990; Chou 1986). Also, the figures used in this document display spatially the country's coastal area.

Coastal resources can be conveniently divided into renewable and nonrenewable, but for such a limited coastal area as Singapore's, both of these categories are substantially altered and utilized, if not seriously depleted or destroyed. However, over the last decade, there were determined efforts to conserve and protect some of these resources. Clearly, decisionmakers will have to consider whether the benefits to be derived from their further destruction, which appears to be necessary as a result of development, truly outweigh the benefits to be had from offering them even greater protection. As will be discussed in a later section, even now proposals for the conservation of coral reefs have been made.

The present chapter will discuss the natural endowments of site and location for both coastal land and seaspace before going on to the more traditional types of resources such as mangroves, fisheries and coral reefs. The problem of coastal pollution will be dealt with in Chapter 5 as part of the discussion on management issues.

COASTAL LAND AND SEASPACE

There are considerable variations in the topography and bathymetry of Singapore, as shown in Figs. 3.1 and 3.2, respectively. The limited area of flat land along the coast has been greatly increased by foreshore reclamations (see Fig. 4.4). The drainage system and the impounded water bodies are shown in Fig. 3.3. The dense network of streams attests to the high annual rainfall which is well distributed throughout the year. Most of the runoffs from these rivers have now been impounded in a series of reservoirs along the western and northern coasts of the main island to provide potable water for the country. These large-scale alterations resulting from the physical developments of the coastal land and water have indeed changed the entire biophysical regime of the coastal area of Singapore.

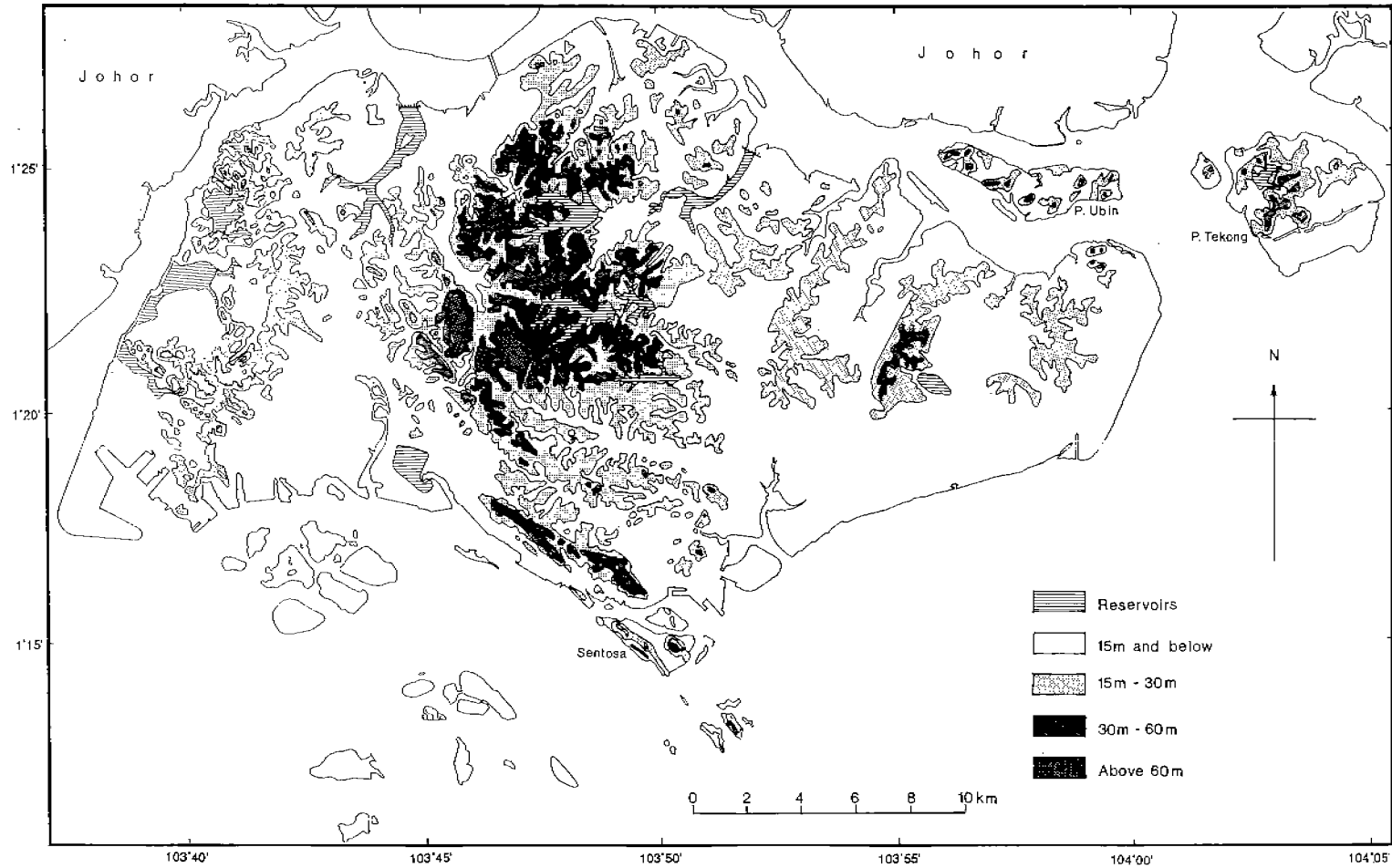


Fig. 3.1. Singapore: topography.

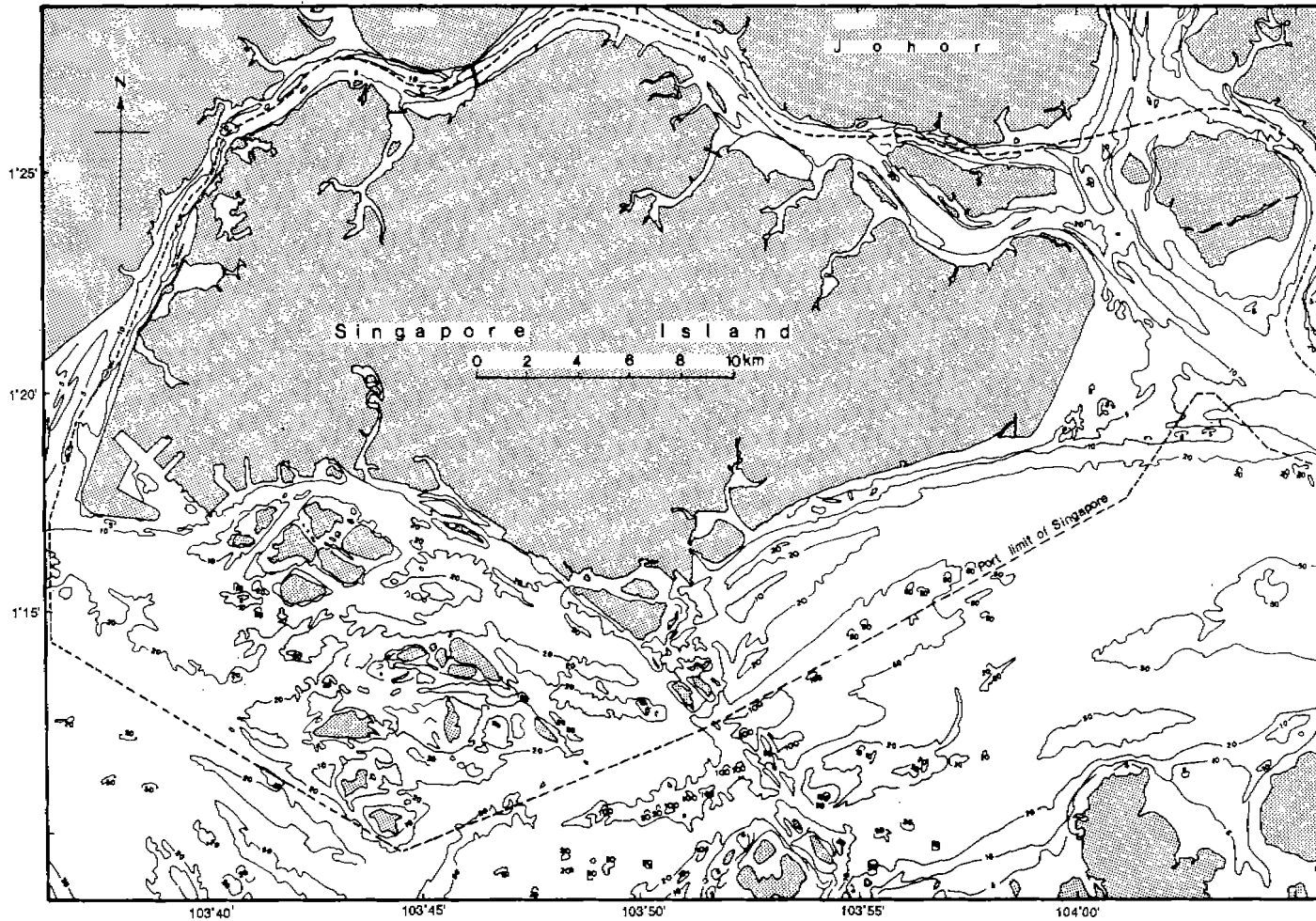


Fig. 3.2. Singapore: bathymetry.

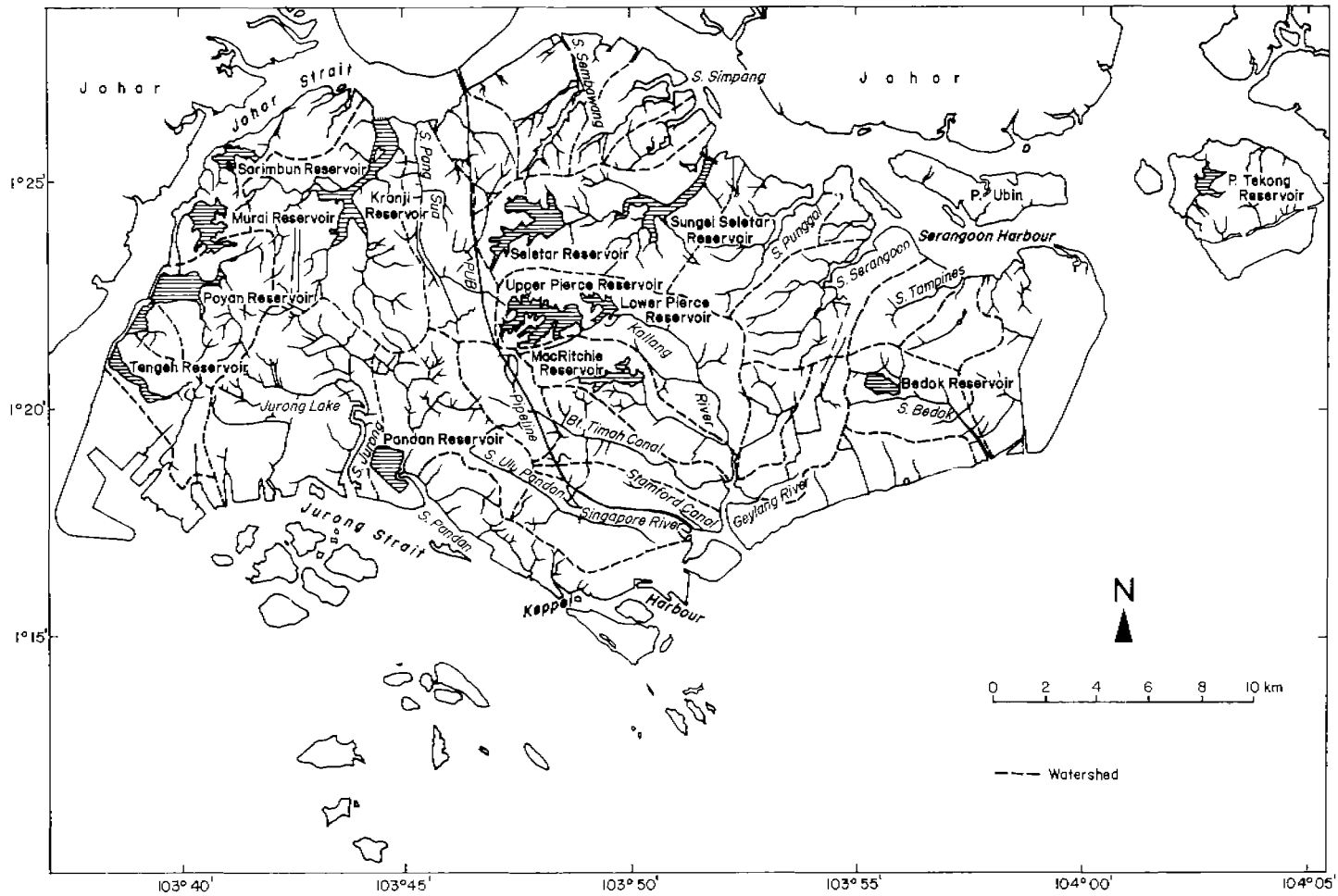


Fig. 3.3. Singapore: reservoirs and drainage.

Singapore can expect to see further massive alterations of its coastal area since land reclamation increases land size at the expense of seaspace.

The main island of Singapore is 41.8 km long and 22.5 km wide, and as of 1990, it has a total land area of 633.0 km². According to Yong et al. (1991), with the completion of the Northeast Coast Project in 1992, nearly 6,000 ha of land, or about 10% of the original size of the main island of 581 km² in 1966, would have been added. This is in addition to the land reclaimed by filling the swampy areas from the earliest days of the establishment of Singapore as a trade settlement in 1819. Moreover, the government has plans to further reclaim about 9,100 ha of land to meet future requirements for land. With these developments, the size of Singapore as a whole would be 25% larger than what it was in 1967. Ultimately, the total area of Singapore would be 730 km² (URA 1991). The length of the coastline is 131.5 km and the offshore islands, a total of approximately 150 km (Tiwari 1991). Details of the revised Concept Plan released by the Urban Redevelopment Authority (URA) in 1991 shows that the reclamation of the southeastern coast will change its shape. However, instead of straightening the coastline and shortening its length, the reclamation will create islands such as Long Island along the southeast coast, those around P. Tekong and elsewhere, while groups of islands off the southwest coast will be consolidated into larger islands (see Fig. 4.4). Singapore can thus expect to see further massive alterations of its coastal area since land reclamation increases land size at the expense of seaspace. This is a matter of considerable concern for port authorities whose vital function is to maintain the use of the coastal space for port operation and shipping to uphold the nation's position as the world's premiere port (see the section on "Transportation and Communications" in Chapter 4). Also to be discussed in Chapter 4 is the use of reclaimed land under the section of "Foreshore Reclamations".

Singapore's territorial waters have a total area of about 600 km². The three-mile limit, which was established by the Territorial Waters Jurisdiction Act of 1878 of the United Kingdom, still applies to Singapore today. It extends from the low water mark up to a distance of one marine league. However, a statement issued by the government on 15 September 1980 has in principle extended the waters to the 12-mile limit. The northern boundary it shares with Malaysia was laid down by an agreement made on 19 October 1927 between the United Kingdom and the Sultan of the State of Johor. It follows the center of the deep water channel in Johor Strait. In order to demarcate the boundary line precisely, the two governments have proceeded to define which part of the deep water channel belongs to each of them since 1980. For its southern sea boundary, Singapore signed an agreement with Indonesia in 1973. However, it remains for the three countries to come together to determine their eastern and western distal triple points (Chao 1989). Moreover, the absolute size of Singapore's territorial waters has yet to be resolved as negotiations on its sea boundary with Malaysia in Johor Strait and with Indonesia to the south are still ongoing. The approximate location of the existing sea boundaries is shown in Fig. 3.4, while most of the local waters which have been designated as port waters under the control of PSA are shown in Fig. 3.2.

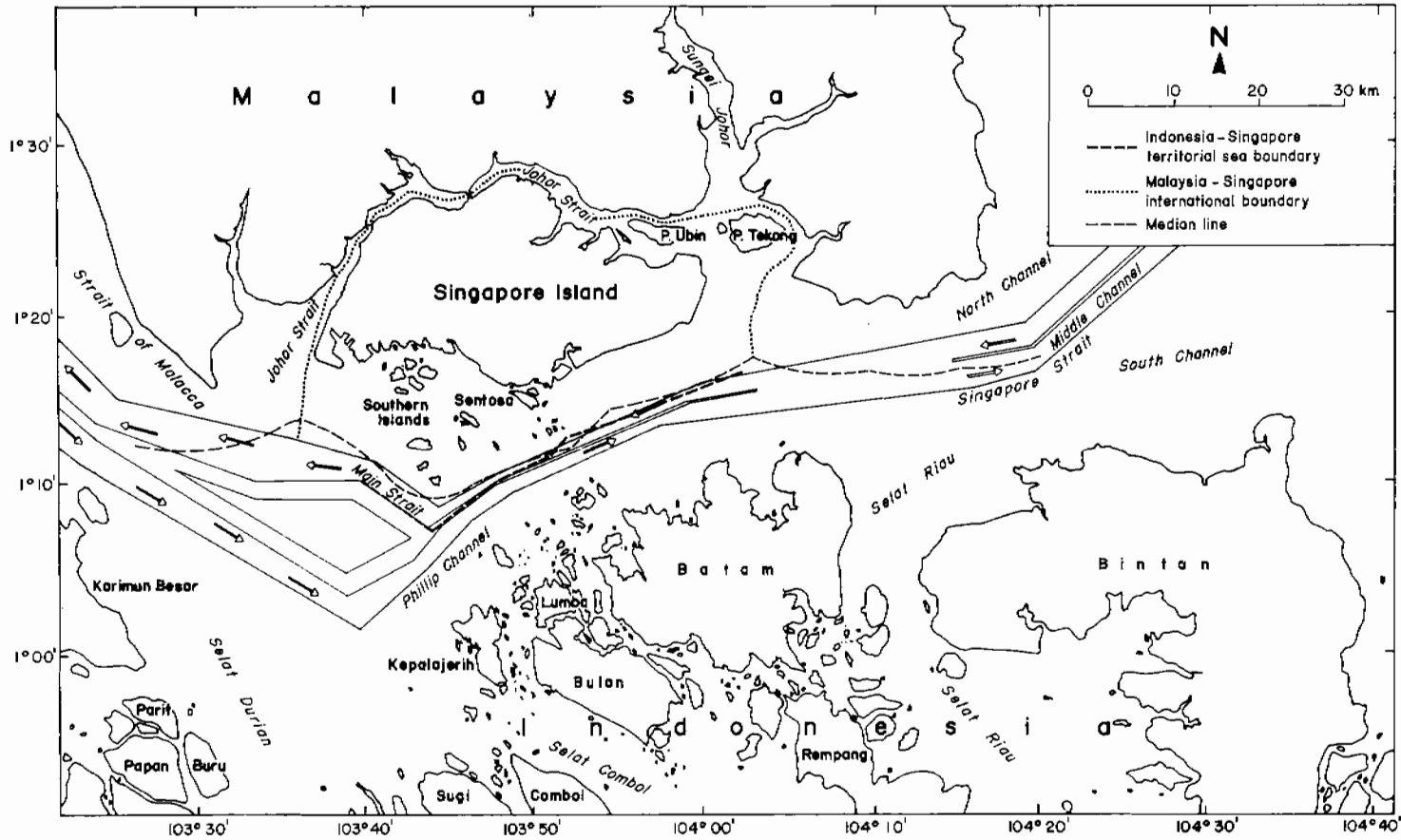


Fig. 3.4. Singapore: neighboring territories, approximate sea boundaries and navigational channels.

Waterfront Land

While flat, low-lying land was essential for earlier agricultural, urban and industrial development, waterfront land with a good elevation close to the coast has the advantage of scenic vistas valuable for residential and tourist recreational uses. And if the surrounding area has minimum obstructions, it may also be used for telecommunications purposes. Mount Faber and Kent Ridge along the southern coast are examples of sites which come close to the sea and provide an excellent seascape as well as the cityscape lying to the east. Along the northern coast, hills come near the coast in many places and again offer the advantage of elevation, giving the location a commanding coastal view. The two largest offshore islands of Ubin and Tekong are hilly and, in a few places, the hills abut on the coast. Other islands with good elevations are Sentosa, P. Sakijang Pelepah and Sakijang Bendera (or St. John's Island) to the south of the main island.

It is important that these coastal resources are protected by prohibiting the erection of tall structures that may obstruct the view of the sea. Already, there have been court cases involving disputes arising from the building of subsequent apartment blocks seawards of the apartments originally built along the coast to take advantage of the picturesque scene.

Besides these scenic vistas, Singapore, a maritime city (and nation) offers waterfront sites for commercial, industrial, recreational and other uses. The commercial center, CBD, has a waterfrontage. New land in Marina Centre and Marina South around Marina Bay (Fig. 4.11) and the city's downtown area will eventually expand the use of the city's waterfrontage. Then there is Jurong Town, the largest planned industrial area deliberately set up on coastal land to take advantage of the Port of Jurong which will conveniently serve the industries there. Recently, the town was expanded with the creation of the reclaimed land in Tuas. Other planned industrial estates include Kranji, Sembawang and Loyang along the northeast coast (Fig. 4.9). The waterfront sites are likewise used for coastal recreation and tourism and brackishwater aquaculture including the traditional shrimp pond farming (although it will be phased out in time in favor of agrotechnology parks). Many of the country's major parks are coastal, the largest one being the East Coast Park (Fig. 4.13). The earlier airport at Kallang (replaced by the Paya Lebar Airport in 1956) and the present Changi Airport (operational in 1980) are located on the coast.

Offshore Islands

There are at present 60 odd offshore islets. The largest is P. Tekong to the east of the main island and the second largest, P. Ubin, is in the eastern Johor Strait. Many of these islets are fringed with coral reefs, and there are those with exposed reefs especially during low tides (Chia et al. 1990), while those that have undergone enlargement through foreshore reclamation (Fig. 4.4) as well as those along the coast of the main island have completely lost their reefs. The 43 islands to the southwest of the main island of Singapore (see Fig. 3.4) are referred to collectively as the Southern Islands. They are separated from the islands of the Riau Archipelago by the Singapore Strait and

have a total area of 22.17 km², with most of them originally having areas of less than 1 km² (Ng 1989). These islands add much to the interest of Singapore and offer certain advantages in spite of being cut off from the main island by the sea. They are particularly useful sites for industrial plants with pollution problems and those dependent heavily on sea transportation. Sentosa, for one, has been developed as a major recreational facility, while other nearby islands offer potential sites for resort development (Wong 1991). The utilization of these islands has been discussed by Chia and Khan (1987).

Seaspace

The coast of Singapore is highly indented but foreshore reclamation has substantially straightened it. This trend will be reversed, as mentioned, in future reclamations when shallow sea areas are removed by fillings. The largest as yet unreclaimed area is a wedge off the Changi coast to the east. The southwestern section of the coast is most suitable for port development and the marine industries of shipbuilding and repairing since the 10-m isobath comes closest to the shoreline. The islands in this area also shelter the ships from high waves and strong winds. This asset is enhanced by the strong daily tidal currents which sweep the port waters clear of silt, rendering the whole of the southern coastal area ideally suited as a natural harbor. Moreover, large parts of the sea surrounding the port waters of Singapore have depths greater than 20 m, thus requiring only minimal dredging to deepen navigational channels to allow large vessels to come unhindered. However, for large modern ships, dredging the channels has become necessary. These areas of open waters lie off the East Coast, east of Changi and to the west of the Southern Islands.

A detailed description of Singapore's marine environment has been given in Chia et al. (1988). On the other hand, Fig. 3.2 shows the considerable variations in its seabed topography. The seabed is highly irregular especially over the waters among the Southern Islands. There are fringing coral reefs around the islands and along the coast of the main island and, at low tide, some of the reefs are exposed. The very strong tidal currents can be treacherous for small vessels and scuba divers. While the open and deep waters can be utilized as fairways for the passage of ships coming and leaving the ports and as anchorages for large vessels, shallower and constricted waters are more suited for small craft.

The waters in Johor Strait are shallower and rendered relatively stagnant due to the presence of the causeway. The deeper western part of the strait allows vessels of up to 30,000 deadweight tons (dwt) to navigate but may be dredged to enable larger vessels to negotiate the waterway. The shallower parts and the calm waters provide suitable sites for marine aquaculture and seaports. Towards the eastern end of the strait, the very large Johor River discharges huge volumes of freshwater and silt into the surrounding areas between P. Ubin and Tekong. Land clearance upstream has tended to

increase the silt load. Thus, there is a need for vigilance to minimize water pollution from agricultural, industrial and other activities on both sides of the strait.

RENEWABLE RESOURCES

Some of the renewable resources are in danger of being lost completely, especially in view of the envisaged additional reclamations in the future.

Except for the more distant offshore islands, the strong developmental pressures involving foreshore reclamations have largely depleted and destroyed much of the swamplands, mudflats, beaches, mangroves and other coastal vegetation, the coral reefs together with the fish and animal life found within these coastal and marine ecosystems. Some of these renewable resources are in danger of being lost completely, especially in view of the envisaged additional reclamations in the future. Efforts should then be made to protect these resources from total destruction and, where possible, to allow regeneration and rehabilitation for other uses for as long as it is possible. The following discussion of mangroves, coral reefs and fisheries is representative of the larger changes in operation.

Mangroves

Mangroves in the Southeast Asian region account for the largest proportion of the world's total mangrove area compared to any other region (Gomez 1980). Today, they are widely distributed among the shallow and sheltered coasts especially in the estuaries of large rivers in ASEAN countries, but in their original state, as estimated by Corlett (1991), they occupied the sheltered fringes of the islands, the river estuaries on the mainland and along Johor Strait (inset of Fig. 3.5). By 1947, a good deal of the mangroves had already been removed through the coastal reclamation of the urban waterfront along the Singapore and Kallang Rivers' mouths and the conversion of large areas in Jurong and along the coast of Johor Strait across Tampines into shrimp ponds (see section on "Aquaculture" in Chapter 4).

Coastal reclamations along the entire southern coast of the main island, some of the Southern Islands, and more recently, the northeast coasts of Pasir Ris, Tampines and Sembawang (Fig. 4.4) have removed much of the remaining mangroves. Mangroves will not regenerate on the foreshore areas of reclaimed land because of the drastic changes in the ecological condition of their habitat. Steepening of the shore profile, curtailment of the supply of sediments and nutrients, and marine pollution have together removed all possibilities of mangrove regeneration. The loss of these mangrove fringes has made the coastal scene very different from its original natural condition unlike that found on the islands and coasts of Peninsular Malaysia. Today, isolated patches of mangroves remain on P. Ubin and the northern shores of P. Tekong Besar, along the northwest coast of the main island, and on a few of the smaller Southern Islands. P. Damar Laut, a tiny island off Jurong Port, has been cleared of its mangroves only in 1990 to accommodate the expansion of the port, while efforts have been recently extended to preserve the small area of mangroves in Kranji for recreational purposes (see section on "Tourism and Recreation" in Chapter 4).

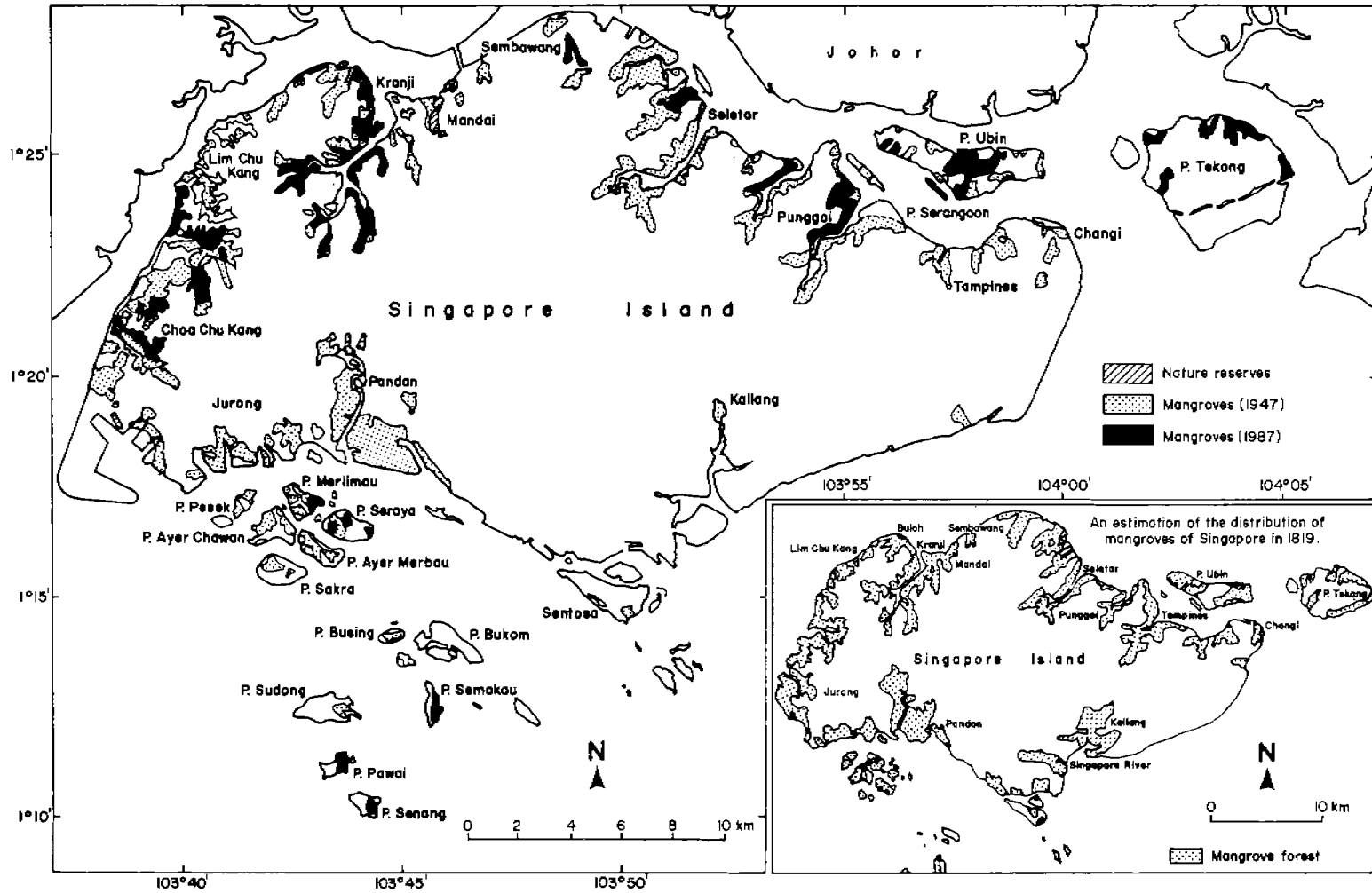


Fig. 3.5. Singapore: mangroves and nature reserves.

Coral Reefs

The reefs of Southeast Asia are highly productive and thrive in warm waters of above 20°C. They are best developed as fringing reefs in shallow clear waters along a stretch of coast or around islands. Apart from the abundance of marine life in reefs, like the commercial fish, they are valuable in their beauty and potential use for tourism and leisure activities. In Singapore, 66 of them occur as patch and fringing reefs (Chia et al. 1990) (see Fig. 3.6 for distribution). There are 57 species of scleractinian corals identified around P. Salu and 86 species of hard corals in the waters around P. Hantu (Chong 1985). There are also unique coral and fish species found in local waters. Details of coral reefs in Singapore are given in Chou (1986; 1988); Chou and Teo (1985); Chou and Wong (1985); and Chia et al. (1990).

The country's coral reefs undergo a similar sequence of change as the mangroves, although their removal is less complete. The main cause of their destruction has been the land reclamation of both the foreshore areas of the main island and the offshore islands down to the steep slopes of the outer edges of the reefs. Other adverse activities include: silting from the dredge and fill process of land reclamation; dumping of unwanted soil (e.g., marine clay), movement of ships as well as dredging done to clear and deepen the channels for navigation and port operations; oil and other marine forms; coral mining (no longer carried out); and removal of corals by ornamental coral makers and collectors (Lee et al. 1991). Unlike birds which are protected by law, there is no similar legal mechanism for preventing the collection of and/or damage to corals. If uncontrolled, this damage to corals can likewise easily wreak heavy damage to the reefs.

Chou and Chia (1991) report that in spite of the high levels of sedimentation and the losses from the activities mentioned earlier, the coral reefs in Singapore have been able to survive well in the upper reef slope zones although there appears to have been changes in the species composition of these corals and their associated marine life. However, Chou (1988) adds that there are long-term effects of sedimentation on the reefs, especially when land reclamation activities come to an end at some time in the future and the quality of the water rises. Provided that care is taken to avoid the disturbance of the ecological conditions on the landward side of the reefs, there should be a vigorous regeneration of the coral reefs in the waters around Singapore. Lim et al. (1989) report that the reefs are already in the recovery stage. Mention should also be made of the survey on the reef fish communities in Singapore by Lim and Chou (1989).

Seagrasses and Algae

Seagrass beds are found in sheltered shallow waters (down to the 20-m depth) often in association with coral reefs. Algae or seaweeds grow in areas where there is a hard substrate and where seagrasses grow. Like coral reefs, marine vegetation in Singapore has been highly disturbed mainly as a result of dredge and fill activities. Seagrasses require clean water with good light penetration. They do not regenerate easily in dredged areas and are known

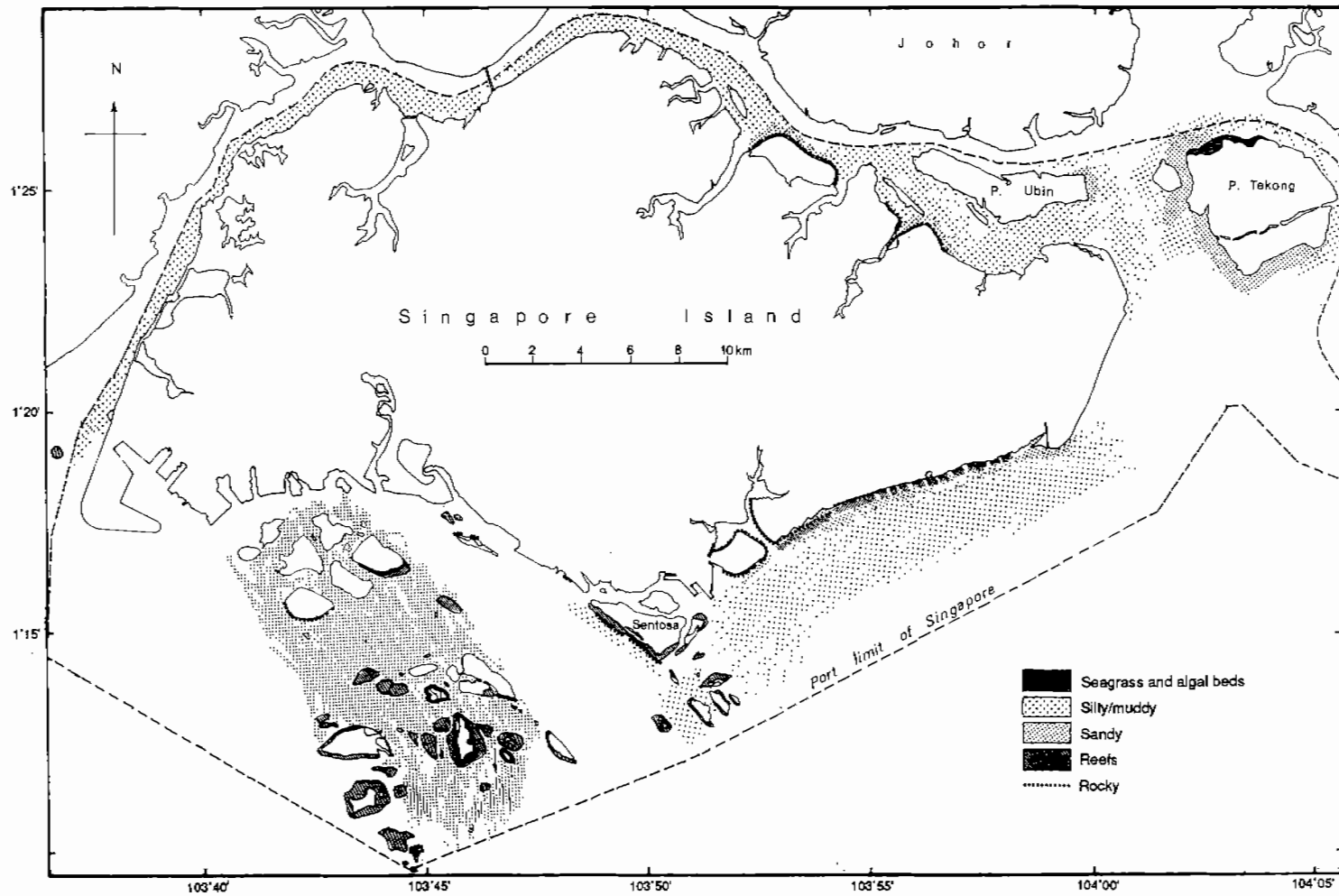


Fig. 3.6. Singapore: marine biota and seabed conditions.

to be sensitive to the warm waters discharged from power generation plants (Snedaker and Getter 1985). Seagrass beds provide habitats for many species of marine fish and organisms. Teo and Wee (1983) have studied the taxonomy of seaweeds in Singapore; Hsu and Chou (1989) have described the seagrass communities in Singapore; while Chou and Wong (1984) have reported the distribution of macroalgae on P. Salu. There are only a few remaining seagrass beds in the country. The largest area is found in the waters to the north of P. Tekong Besar and around P. Semakau in the south (Fig 3.6).

It is clear that to preserve what little is left of the coral reefs, seagrass beds and their associated assemblage of marine life, it will be necessary to find ways to accommodate them without sacrificing developmental goals. They will also need to be managed in ways that will allow them to regenerate and be rehabilitated to render them accessible for recreational uses. Prospects of their survival appear to be slim in view of the very extensive foreshore reclamations to be undertaken in the future (URA 1991).

Marine Fisheries

There have been no systematic surveys of fisheries resources except on the coral reef fish in Singapore (Lim and Chou 1989) since it is not feasible to do so until major disturbances in the marine environment come to an end. In the late 1940s and early 1950s, total marine fish production reached a maximum of around 40,000 t. Today, while traditional inshore fishing methods are still used, palisade traps (locally known as *kelong*) have diminished considerably in number. Their distribution from the 1950s to the present is shown in Fig. 4.15. Although there will always be space left for recreational fishing, marine capture fisheries within local waters will always remain a minor activity due to the lack of local fishing grounds as well as the availability of other much better-paying employment opportunities. It was reported that, in 1984, Singapore-registered fishing vessels accounted for a quarter of the 118,000 t of fish landed at the ports (Chao 1989).

Disturbances to the marine environment and the habitats supporting marine fisheries have been responsible for the decline of the fish stocks in local waters. However, with the current reduction in reclamation activities along the southern coast, a greater abundance of fish has been noted. Also, the cleaning up of the Singapore and Kallang Rivers and the restocking efforts on the part of the Marine Aquaculture Section (MAS) of PPD have reported some positive results.

The waters around Singapore are rich in a number of shrimp species traditionally harvested by the local fishermen using push nets. Chinese shrimp ponds built in estuaries and mangrove areas utilize the tides to entrap the larvae and juveniles, which are later raised with supplementary feeds and harvested when mature. The distribution of shrimp ponds at the height of their development in the 1950s and at present is shown in Fig. 4.15. With the increasing use of coastal land for development purposes, shrimp ponds will

be things of the past in the not too distant future. Instead, shrimp cultivation will be increasingly carried out in especially allotted high-technical farming areas.

**NONRENEWABLE
RESOURCES**

Due to the small size of Singapore, there can be no extensive nonrenewable resources within the coastal area. The only resources of commercial value are sand and gravel from the eastern part of Singapore underlain by the Older Alluvium and granite quarried in the northern central part of the main island and on P. Ubin.

Sand and Gravel

The effectiveness of sand washing in the Tampines area and other such methods employed elsewhere has to be assessed in terms of the silting problems these activities can create for the marine environment. Much of the pollutive aspects in Tampines is said to have been controlled. Sand for construction purposes is imported from Johor. This as well as fill materials are dredged from the seabed in nearby Indonesia and brought in by barges for foreshore reclamation. A recent report brought to light the case of the illegal removal of sand on the northern coast of P. Ubin which led to the prosecution of the offenders (*Straits Times*, October 1991 issue).

Granite

Granite chips and blocks provide materials for the construction of roads and buildings. Some of these are imported from Peninsular Malaysia and the Riau Islands in Indonesia, while others are produced on P. Ubin, creating deep pits and badly scarring the landscape. Heaps of granite of varying aggregate sizes as well as granite dust lie on the land behind jetties before these are transported by barges to receiving jetties at Sembawang on the main island.

Mudflats

Little is known of the condition of the seabed in Singapore's waters—the distribution of areas that are muddy, sandy or rocky; the occurrence of sea vegetation; or the occurrence and abundance of marine life, except that there is little left from the foreshore reclamation works carried out thus far. Thomas (1991) suggests that there is an abundance of sediments in the surrounding waters due to the erosional history of the region. Locally, it is likely that where the tidal streams are strong, as in the constricted areas between small islands, the seabed may be cleared of its sediments. But for mudflats, these are maintained by the continual influx of fine sediments that settle as mud and silt, although patches of sand may also be found. Seagrasses and seaweeds do not grow on mudflats as their substrate is too soft to hold the roots, and this is likely to be the condition seawards of mangrove areas.

Due to the small size of Singapore, there can be no extensive nonrenewable resources within the coastal area.

Beaches

Singapore has a low-energy coastal environment and is not endowed with wide sandy beaches. Beaches are valued for their recreational and tourist uses, thus, efforts have been made to create them artificially by means of physically putting sand brought in from elsewhere and then building protective structures to prevent beach erosion (Wong 1985). Such efforts have met with success. Some of the best sandy beaches are found along the East Coast and Changi. Wong (1991) also describes the occurrence of beaches in Singapore. There are reasonably good beaches along the northeast coasts, as in Pasir Ris. Small stretches or enclaves of sandy beaches are also found on the offshore islands.

CHAPTER 4

COASTAL RESOURCES USES

This chapter discusses the uses of and activities arising from coastal resources. It will first deal with land use planning and foreshore reclamation to provide some essential background. Then, it will consider the major uses of coastal land and seaspace, such as population settlements; transportation and communications, of which the most important are port operations and shipping; manufacturing industries including marine, oil and related industries; commercial uses; tourism and recreation; and defense and security. The discussion on the activities that relate to the exploitation of various other resources such as agriculture, marine fisheries and aquaculture will follow. Finally, a section is devoted to marine science and education. Attention is given to the importance of these uses; the problems encountered, including conflicts with other uses; and the existing management measures, which relate to the avoidance, if not the minimization of pollution and environmental degradation.

LAND USE PLANNING

The generally orderly pattern of land use has come about through a long process of physical land use planning beginning with the 1955 Master Plan.

The present pattern of land use is shown in Fig. 4.1. The core of the main island is the central water catchment area. The heavily built-up areas for residential, commercial and industrial uses are located around the central green core and in a belt along the entire southern coastal area of the island. To the north, especially the northwest, are the less intensively developed agricultural areas which have been rapidly giving way to other land uses. The main commercial area comprising CBD forms a wing on each side of the Singapore River and an inland branch along the Orchard Road corridor. The largest industrial area is in Jurong with the recently reclaimed Tuas area taking up a large portion of the West Coast. There are other planned industrial estates, such as Sembawang to the north and many smaller ones scattered across the island. Many of the offshore islands are also earmarked for industrial development. A good part of the northwest coast and P. Tekong has been categorized for "special use" for defense and security. Finally, there are significant areas under the category "open space and recreational". These include Sentosa Island, the islands directly to the south of it, and most of the East Coast (Fung 1991).

The generally orderly pattern of land use has come about through a long process of physical land use planning beginning with the 1955 Master Plan, a statutory instrument responsible for the orderly physical development of the

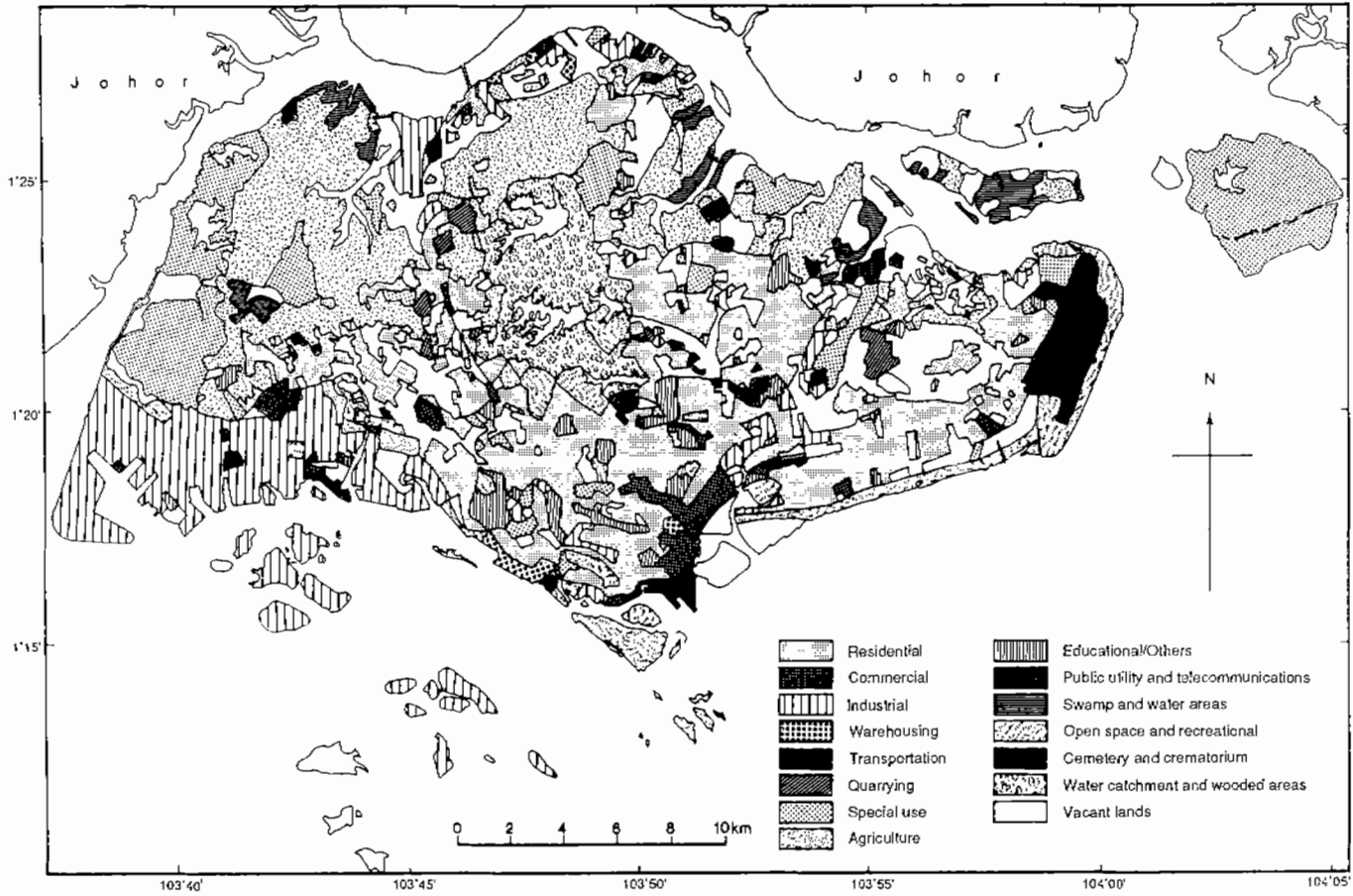


Fig. 4.1. Singapore: land use.

Chapter 4. Coastal Resources Uses

country. It was administered by the Planning Department of MOND until 1989 when it was transferred to URA. Subsequently, the Long-range Comprehensive Concept Plan, referred to also as the "Ring Plan," was adopted in 1971 to provide guidelines for future development plans as a complement to the Master Plan. The Master Plan is revised every five years; at present, detailed comprehensive plans have been laid out for small areas which indicate the high degree of planning undertaken in the country. (See Master Plan Review 1985 issued by the Planning Department for the latest available description of Singapore's land use.)

In September 1991, URA unveiled details of the revised Concept Plan, the result of a three-year intensive study and consultation among all development agencies (URA 1991), through a series of press releases (*Straits Times*, 13-15 September 1991 issues) and an exhibition called "City Trans Asia '91." The plan redefined the basic planning parameters in terms of the target population; commercial, industrial and other space requirements; and the three proposed plans for staging in the years 2000 and 2010 and Year X when the population is expected to reach 4 million. The land use pattern envisaged by the plan is shown in Fig. 4.2. A part of the vision of the planners is expressed as follows (URA 1991): "An island with an increased sense of islandness—more beaches, marinas, resorts and possibly entertainment parks as well as better access to an attractive coastline and a city that embraces the waterline more closely as a signal of its island heritage."

An important factor that bears on land use is that the government—mainly MOND and several development agencies—owns over 60% of the total land area of Singapore. The pattern of landownership along the coast, including those owned by various government agencies, is presented in Fig. 4.3. Except for the patches of land within and to the west of CBD, along the East Coast (but not along the waterfront which has been reclaimed), and on P. Ubin, almost all of the land is publicly owned. The process of CAM is, therefore, considerably simplified since it is not necessary to involve private individuals or entities.

FORESHORE RECLAMATIONS

A good deal of discussion on foreshore reclamations has already been done in the earlier sections of this report, but since this activity has been overwhelmingly the most important process of coastal change, the topic resurfaces here. The demand for land in urban areas is such that it has become cheaper to reclaim land from the sea than to buy existing land and remove their existing uses. Fig. 4.4 shows the sections of the coast on the main and offshore islands that have been enlarged through foreshore reclamations as well as the area that may be reclaimed eventually. The figure also shows the agency responsible for the reclamation works. Details of land reclamation have been amply provided in Chia et al. (1988) and need not be repeated here. Currently, reclamation is restricted to the depth of the 10-m isobath,

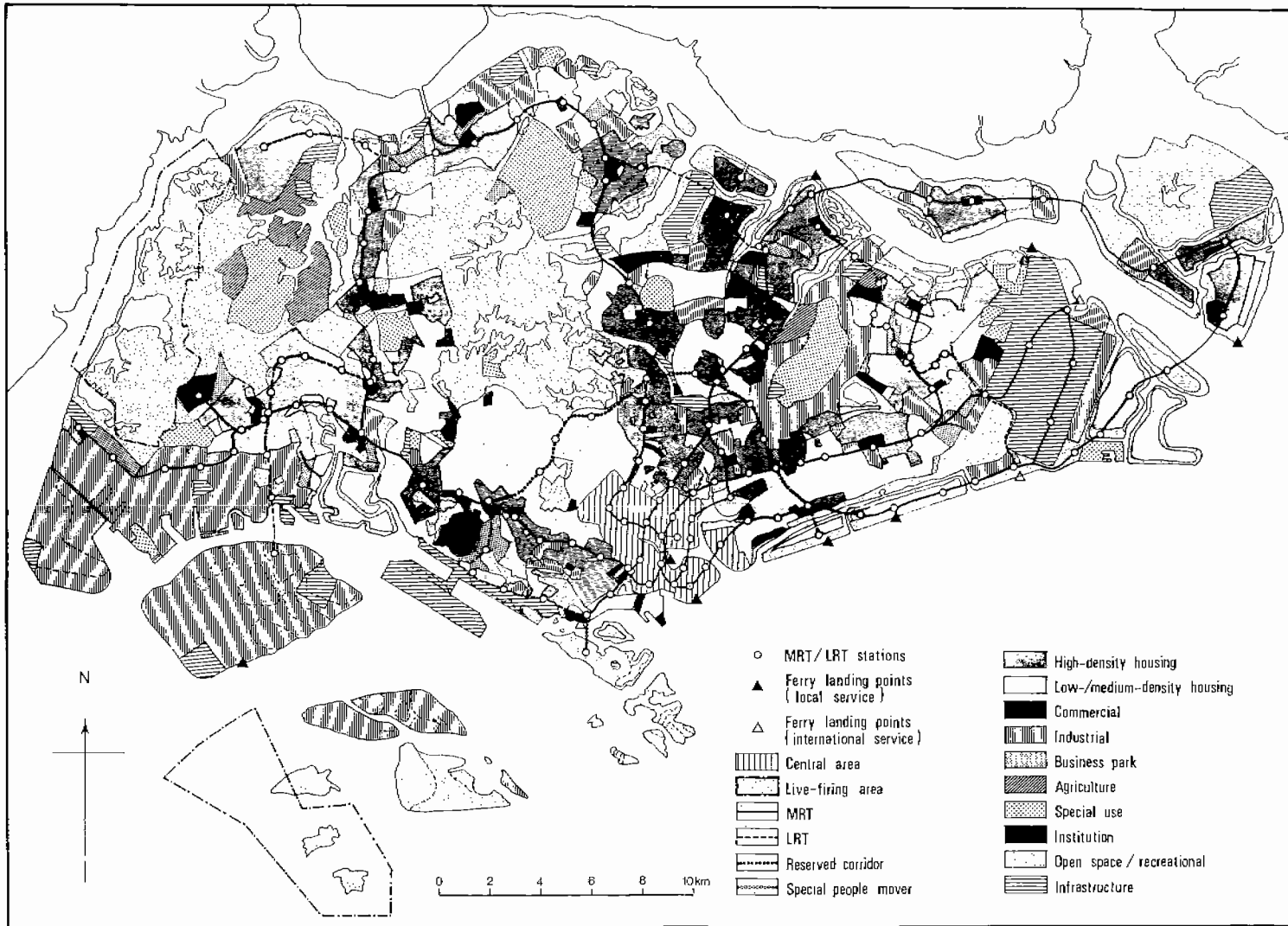


Fig. 4.2. Singapore: revised Long-range Comprehensive Concept Plan.

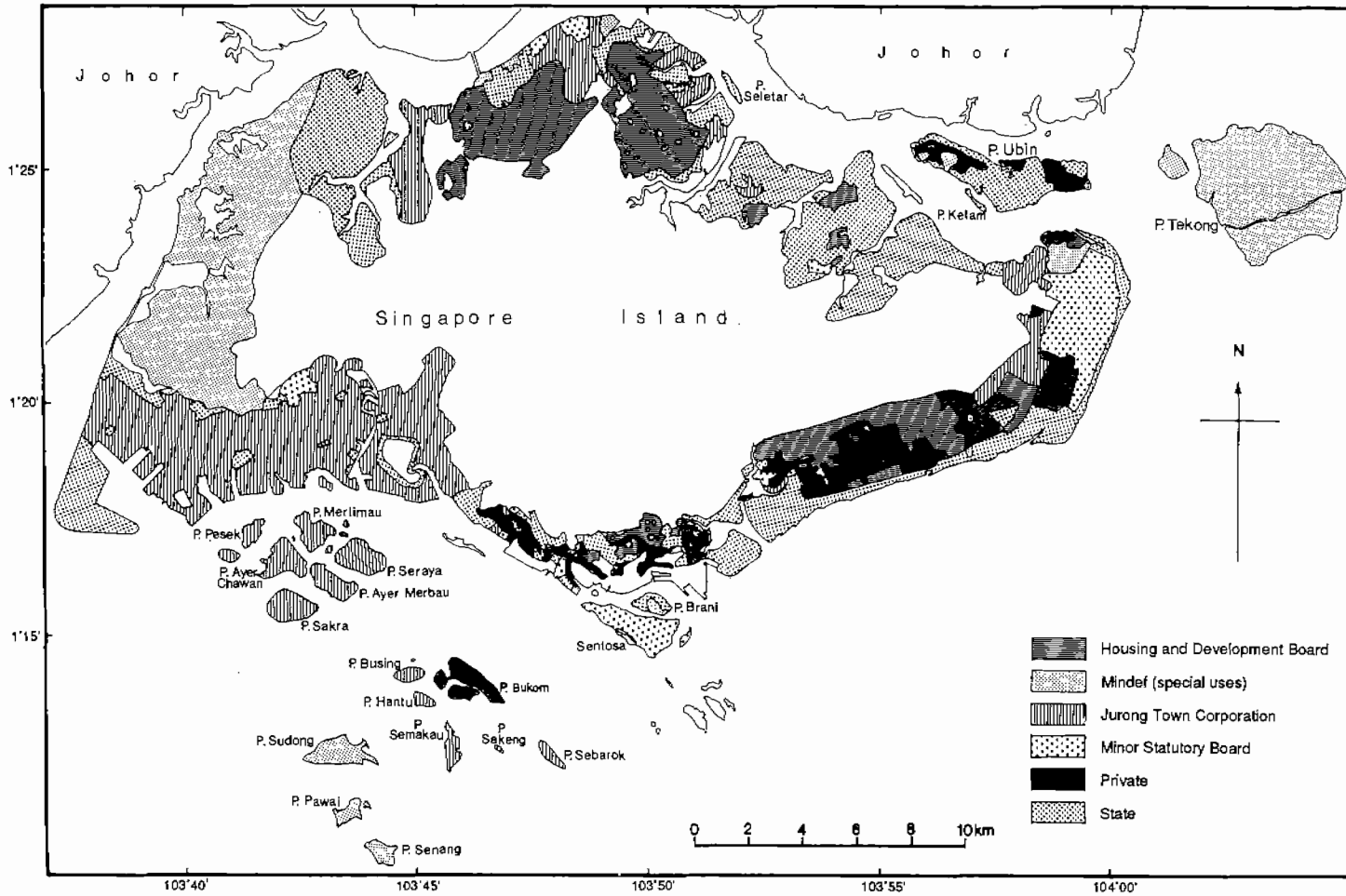


Fig. 4.3. Singapore: landownership.

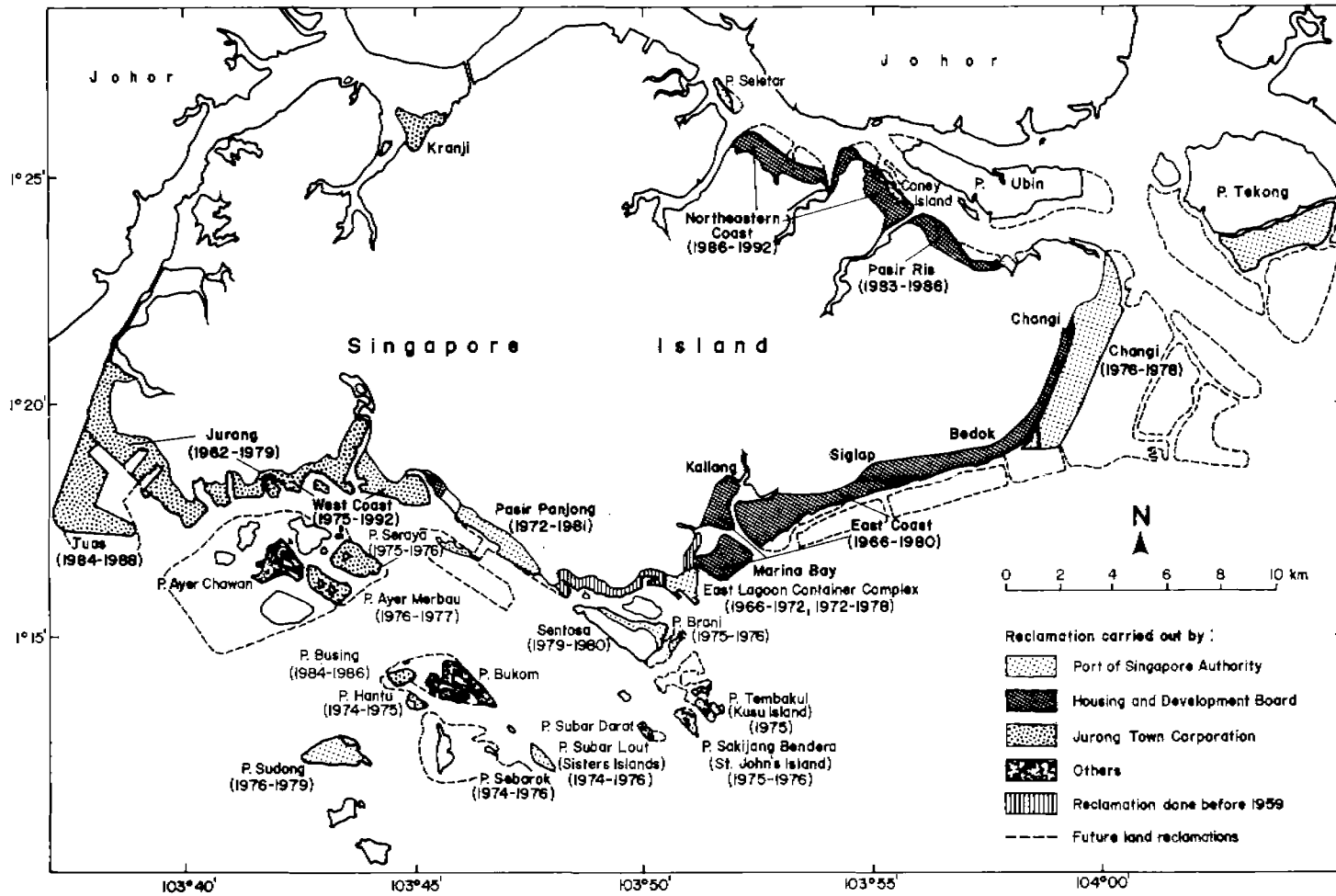


Fig. 4.4. Singapore: foreshore reclamations.

Chapter 4. Coastal Resources Uses

The demand for land in urban areas is such that it has become cheaper to reclaim land from the sea than to buy existing land and remove their existing uses.

although technology is already available to reclaim land up to the 15-m depth, its feasibility depending entirely on the cost of the undertaking and the need for the land (Yong et al. 1991).

Traditional and preexisting coastal uses and activities have been cut off from direct access to the sea as a result of the reclamations. Privately owned lands along the coast have lost their sea frontage without compensation. Coastal (and island) settlements have been relocated and, along with them, the traditional house styles along the coast and such an activity as fishing. Various seaports facilities and activities along the entire southern coast have also been removed (Lee 1991). However, land reclaimed from the sea has provided the additional space to meet urgent developmental needs, including industrial uses, the improvement of Changi Airport and the expansion of the vital central urban area into the reclaimed land of Marina Centre and Marina South. Surplus waterfront lands have been put to good use too as public parks, with the possibility of using them in the future for more intensive forms of development.

POPULATION SETTLEMENTS

The population has been redistributed across the entire country.

As a result of the highly successful public housing and urban redevelopment backed by effective physical planning, the population has been redistributed away from the central urban area to different places across the entire country (Fig. 4.5). The main agency responsible for this has been the Housing and Development Board (HDB) in conjunction with URA and the Jurong Town Corporation (JTC). If the coastal population includes those residing in constituencies that abut on the coast, then by the 1980 census count, it represents 61.5% of the total population (Chia et al. 1988).

According to the revised Concept Plan, encouragement will be given to the development of waterfront housing and communities (URA 1989):

The settlement can exist in harmony with the water. Developers can maximise the closeness of the water as they sculpt the town. Houses will be based near, and possibly even on, the water. Walkways enabling people to gain access to the water's edge will be a key element as will beaches, marinas, recreational facilities. Having a boat near the backyard will no longer be just a dream. The natural side of life will not be forgotten with the provision of a nearby bird sanctuary.

New Towns and Public Housing Estates

HDB's public housing program has created large new towns, some with over 200,000 residents, as in the cases of Toa Payoh and Ang Mo Kio. Existing housing, whether public or private, with few exceptions for the latter, are built near the coast but are not actually on the waterfront. In a large part, this has been the result of the very extensive foreshore reclamations mentioned earlier and HDB's deliberate policy. The exception is Pasir

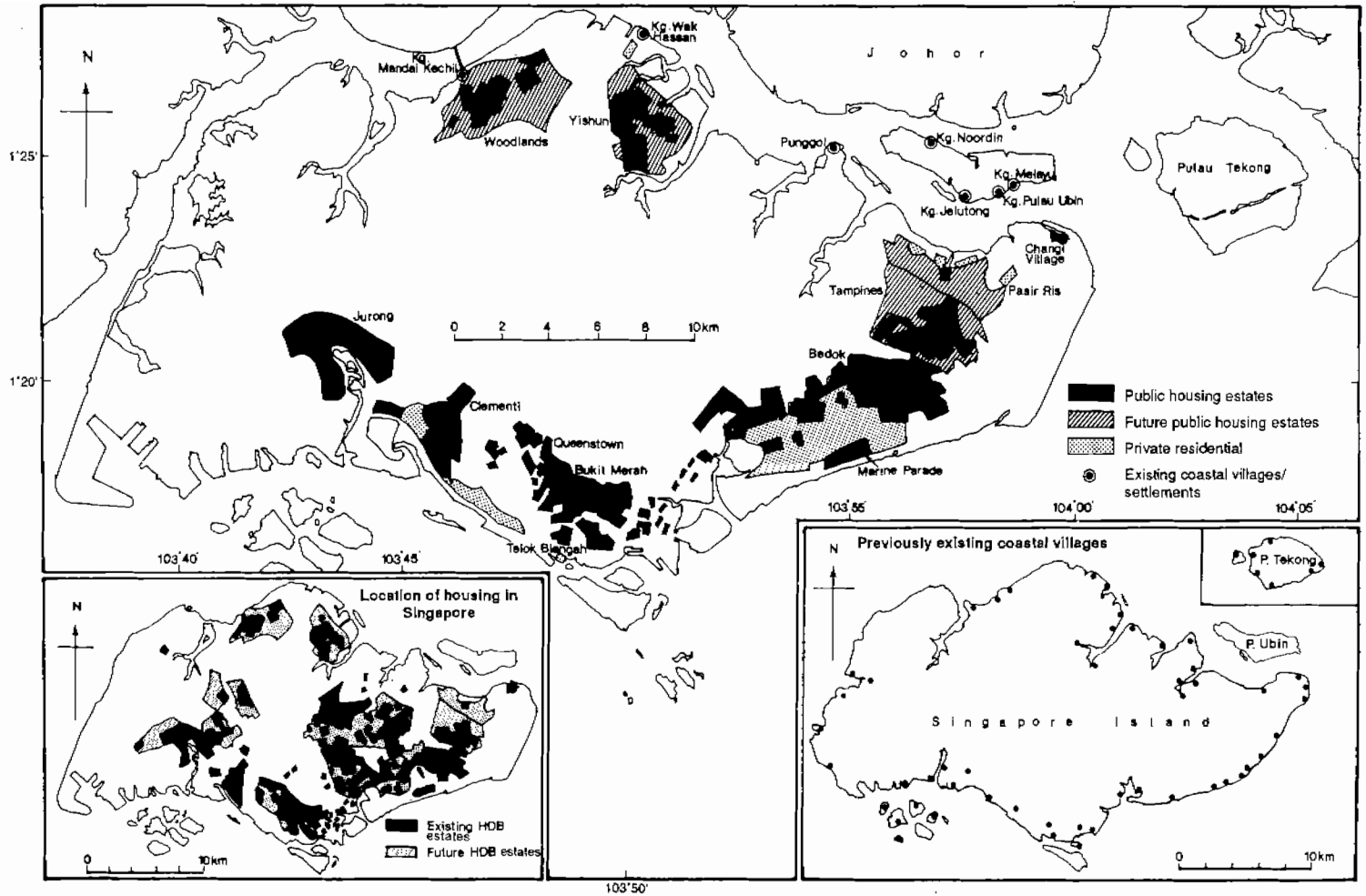


Fig. 4.5. Singapore: population settlement.

Ris New Town on the northeast coast which is now being developed to take advantage of its coastal location. To this end, HDB is promoting the town to attract residents on the basis of being a coastal township to be served by the mass rapid transit in 1989. In a related development, a small public housing estate in Marine Parade was built on reclaimed land along the East Coast around the mid-1970s. The people's initial concern was whether the reclaimed land provided a sufficiently firm foundation for the tall blocks of apartments. Now, with the easy accessibility of recreational facilities along East Coast Park, this housing estate has gained popularity.

It must be noted, however, that some of the new towns are several kilometers or 10-15 minutes from the coast, as in the cases of Bedok South, Telok Blangah, Clementi South and Woodlands, although several townships along the West Coast are physically separated from the coast due to the use of the waterfront land for port and industrial uses, except for West Coast Park east of Jurong Town which provides easy access to the coast. Access to the East Coast for people living in public housing and private residential areas along the coast as well as from all over the island, on the other hand, is convenient since the East Coast Park occupies a very long stretch of the coast and is contiguous with the park along Marina Centre.

For the future, new types of coastal townships will be created. Among them is Simpang on the northeastern coast which will comprise a mixture of high-, medium- and low-rise houses and allow private participation in its development (URA 1991). In addition to Simpang, a modern Kampong Bugis will rise on the shores of Kallang Basin for residential and commercial use.

Private Housing

Many gracious seaside private housing along the southern and northeastern coasts have lost their waterfrontage as a result of land reclamations. The Foreshore Act provides for no compensation for the loss, but the revised Concept Plan promises to restore private and resort waterfront housing. Recently, the Tanjong Rhu site was sold to a private developer which will construct on it a condominium with waterfront facilities, including a marina. The revised Concept Plan also envisages housing along Singapore River and resort housing at Buran Darat which will be connected to Sentosa and the main island by a causeway (URA 1991).

Traditional Villages and Island Populations

Singapore used to have its own floating villages (*kampong*) similar to those in Kampong Ayer in Brunei Darussalam. They existed on P. Brani near Sentosa as well as within Kallang Basin which was reclaimed in the mid-1930s to make way for Kallang Airport. Today, few of these earlier villages along the coast have survived the widespread land reclamations; the remaining ones are found on P. Ubin and along the north shore. Island populations were also affected as a result of the conversion of many of the offshore islands in the Southern Islands for industrial development. The residents were displaced

when the size of the island was enlarged by reclamation to accommodate the industrial plants that were installed there (Chia 1985; Chia and Khan 1987; Chia et al. 1990). Today, only P. Saking in the Southern Islands and P. Ubin in the east of Johor Strait remain populated by the original islanders, although the former has been earmarked for industrial development. As for Singapore's largest island, P. Tekong Besar, its residents were relocated to the mainland when the government acquired a privately owned land which it is now using to accommodate its military training facilities, although the land has also been earmarked for industrial development in the future. The inset in Fig. 4.5 shows the distribution of previously existing coastal and island population settlements in the villages along the coast.

TRANSPORTATION AND COMMUNICATIONS

The operation of air- and seaports and marine transport, together with coastal industrial and commercial uses, constitute perhaps the most important uses of the coastal area of Singapore.

Various transportation and communications facilities are vital to the operation of an island-nation (Fig. 4.6). The operation of air- and seaports and marine transport, together with coastal industrial and commercial uses, constitute perhaps the most important uses of the coastal area of Singapore. Although Changi Airport occupies a relatively small portion of the coast, its contribution to the economy and influence on the surrounding users far outweigh its relatively small size. The airport's coastal location offers the advantages that (1) it can be expanded through foreshore reclamation and (2) it minimizes the level of noise pollution affecting the surrounding areas.

The network of roads, specifically the coastal roads, the causeways linking Singapore to Peninsular Malaysia and those planned to link the offshore islands as well as the pipelines for various purposes, are also major factors to consider in the assessment of the local coastal area. Moreover, there are numerous telecommunications facilities located on the coast, the offshore islands and the seabed to provide the essential links domestically and with the rest of the world.

Port Operations and Shipping

The strategic location of the island-nation for international shipping and the favorable natural physical attributes of its coastal waters have enabled Singapore to achieve the status of a world-class seaport. Such an achievement underpins the country's economic success. In 1990, Singapore's external trade totalled S\$205 billion which is more than three times the country's GDP of S\$62.7 billion for the same year (DOS 1990). Its efficiency and extensive shipping services have ensured the trading nation its continued success both as an entrepôt trader in the international and domestic markets and a local trader engaged in the export of its manufactured products. Since the end of World War II in 1945, the port has continually been expanded and modernized (Chia 1989). Today, some 600 shipping lines regularly call at the port. It is linked to the major shipping routes that serve the Europe/Far East and Europe/Australia and New Zealand trade markets. It is also the shipping hub of the region, continuing to operate as the traditional entrepôt for the surrounding countries.

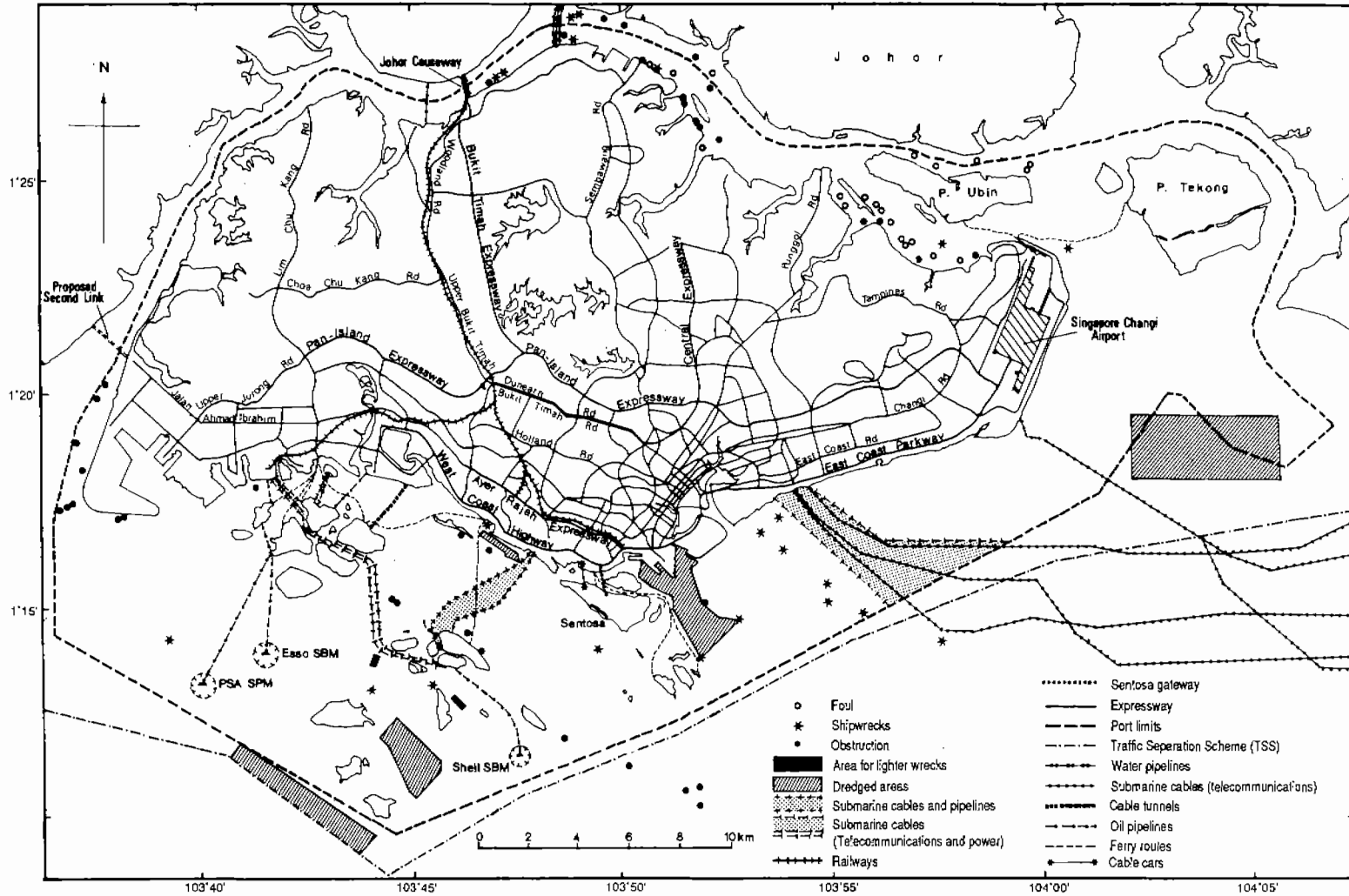


Fig. 4.6. Singapore: transportation and communications.

Since 1986, Singapore's port has retained the position of the world's busiest port. In 1990 alone, the port recorded a total of 44,600 ship arrivals with a total tonnage of 483 million gross registered tons (grt) and a total cargo throughput of 187.8 million freight tons (ft), including 5.22 million twenty-foot equivalent units (TEU) of containers. Since 1989, the port has also been regarded as the world's largest container port, ahead of Hong Kong, and even earned the distinction of being the best seaport in Asia (*PSA News*, February 1989 issue). The revenue generated from port operations by PSA was about S\$525 million in 1986 and S\$542 million in 1987. At that time, the port had about 7,000 workers in its employ (PSA 1987). The port's five gateways--Keppel Terminal, Tanjong Pagar Container Terminal, Pasir Panjang and Sembawang Terminals, and Jurong Port--are shown in Fig. 4.7.

The port has invested heavily in modern cargo handling facilities. The Pulau Brani Container Terminal, now undergoing development, will add 10 more quay cranes to the 13 existing ones. It began operation in late 1991. The island will be linked to the mainland via a recently completed causeway. There is a similar plan for Jurong Port to develop the nearby islet of Damar Laut into a multipurpose deepwater port for handling bulk cargo. It will also be linked to the main island by a causeway. Other new facilities will be the passenger terminal at the World Trade Centre (WTC).

PSA has designated all of its port areas as Free Trade Zones (FTZ) with extensive warehousing facilities for storing, stuffing and unstuffing, sorting, grading and repacking goods for reexport. It also provides direct waterfront access to the manufacturing plants, such as flour and grain milling, cement making, fertilizer bagging, iron and steel milling, sawmilling and wood-working along its perimeter. Some of these plants have conveyor-belt systems for transferring bulk materials from the wharves to the factory sites. In addition, PSA operates WTC, an exhibition, convention, restaurant, shopping and office complex. The Cable Car Tower (previously PSA Tower) and the newly completed PSA building nearby provide the facilities for the administration of its own commercial operations. PSA also manages the fruit and vegetable wholesale market at Pasir Panjang and the fishing wharves on Jurong River.

The oil terminals of major international oil companies (Fig. 4.7) on the coast and offshore islands comprise another important part of the activities on the port of Singapore. Two of the major oil and liquid chemical storage companies are Van Ommereen and Paktank. The former is located on P. Sebarok and the latter, which is currently using an ultra large crude carrier (ULCC), will be permanently located on P. Busing when the facility is completed. The Petrochemical Corporation of Singapore Pte. Ltd. (PCS) has terminals on P. Ayer Merbau to handle the loading and unloading of its feedstocks and other products. Shell operates a storage terminal at Woodlands and Changi Airport has a jetty to serve its fuel storage facilities, and unlike most other

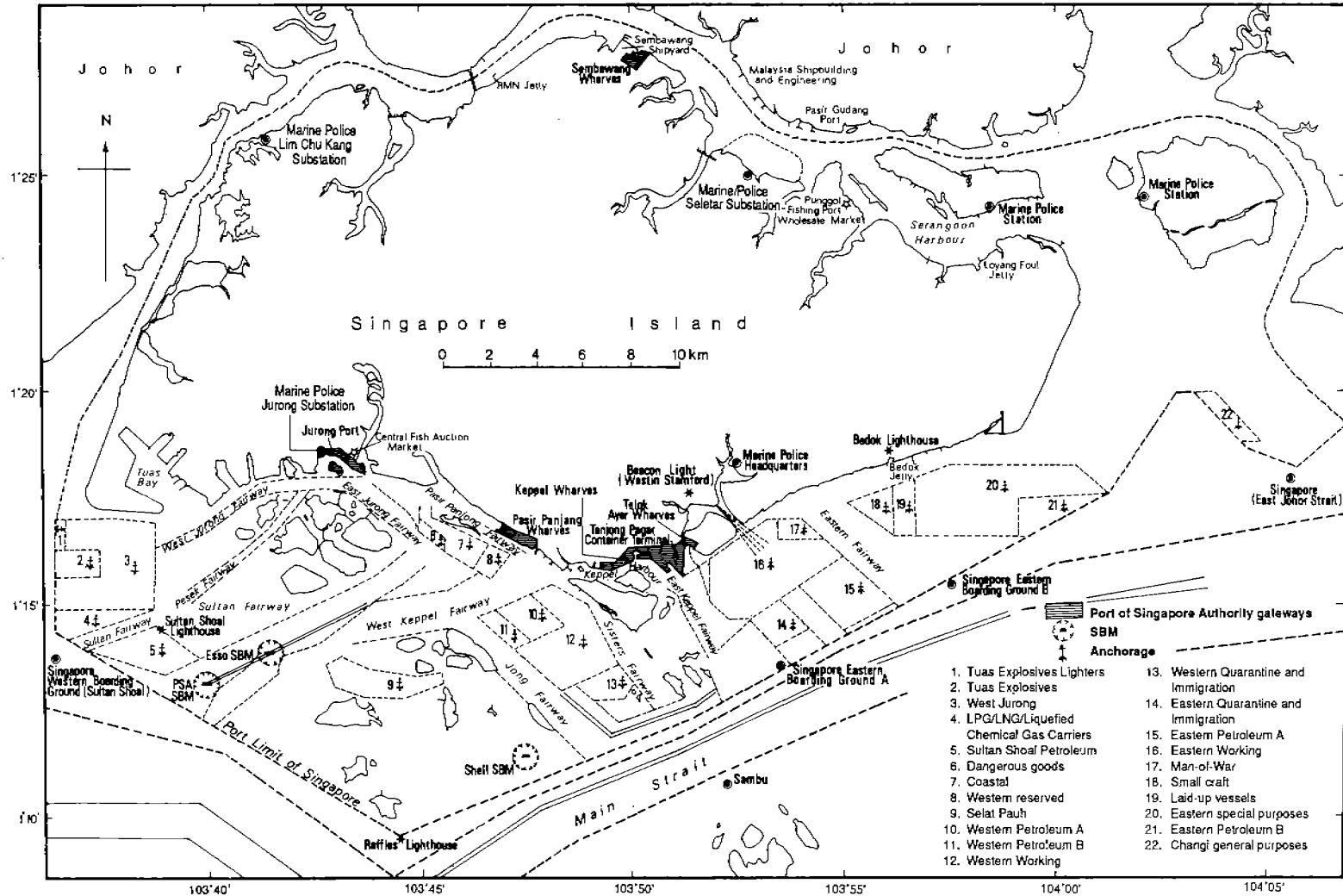


Fig. 4.7. Singapore: ports and harbor.

landing points with bunkering facilities, provides for the ship-to-ship transfer of bunkers and engine oil. PSA also operates barges which carry and remove bilge oil from the ships before bringing it to the Oil and Sludge Treatment Centre (OSTC) on P. Sebarok. All in all, the oil companies provide oil handling facilities, two single buoy moorings (SBM) and oil jetties for bunkering services at the port.

With the very large number of vessels moving through the international shipping channels of the Main Strait and Phillip Channel within and to the south of Singapore's port limits, it is inevitable that there will be inadvertent, as well as deliberate, oil spills. The Malacca Strait Traffic Separation Scheme also operates to the south of these channels (Fig. 3.4). Apart from merchant ships, there are warships, fishing vessels and pleasure craft calling at the port and adding to the oil pollution of the coastal waters. Land sources also introduce petroleum and other pollutants into these waters (Khoo 1991).

Apart from constituting an important source of marine pollution, shipping has other impacts on the marine environment. Very deep-draft vessels can churn up the bottom sediments of the sea and add to the turbidity of the water, making it necessary to dredge some of the shipping channels to regenerate the seabed left sterile of marine life. Areas that have been dredged and deepened for navigation include (1) the entrance to Keppel Wharves and the Tanjong Pagar Container Terminal; (2) the area south of P. Pawai and Senang in the Main Strait; and (3) a small strip at the Pasir Panjang Wharves. Moreover, the physical movement of vessels of all sizes poses a hazard to smaller passenger ships, fishing boats, tugboats and pleasure craft plying the port waters.

The port waters have been divided into navigational channels (fairways) and anchorages for various purposes (see Fig. 4.7 and Lim 1991 for details). Ships larger than 30,000 dwt are required to be guided in and out of Singapore's waters through the appropriate fairways. At any one time, there are about 550 vessels in the port, which means one vessel arriving or departing every 8 minutes (Khan 1991). Over half of the vessels call at the port for services like bunkering rather than the loading or unloading of their cargoes. Many of them dock at anchorages, but in doing so, their very large anchors completely destroy the seabed. The seaspace used for anchorages thus effectively preempts all other users.

Of the total 583 km² of port waters (Khan 1991), their various uses are distributed, according to Lim (1991), as: anchorages (18.8%); fairways, vessel maneuvering areas and unrestricted areas (45%); restricted use for undersea cables and pipelines (5%); military training grounds (5%); and others (26.2%). Lim further reported that the port has a Master Plan on the use of its port waters with the objectives of facilitating economic growth through port operations and providing a clean and safe marine environment for Singaporeans. The first is envisaged to be achieved through the pricing of port

usage, depending on the type of use and locational advantage. It has also adopted strategies to accommodate nonconflicting seaspace for the smooth flow of marine traffic.

Air Transport

Changi Airport is located almost on the eastern tip of the main island. Like the first airport at Kallang, it was deliberately sited on the coast to take advantage of: (1) the foreshore land that can be reclaimed for the runways and (2) the air corridor that can buffer the noise coming from the surrounding area (Fig. 4.6). The decision proved to be well-advised with the recent completion of a second air terminal at Changi. It was opened in early 1991 to cater to the continued fast growth of air traffic.

As the regional hub for air transport, Singapore registered 41,646 aircraft landings, 5.7 million visitor arrivals and 1.2 million transit passenger arrivals at Changi in 1988. The airport also handled over 0.5 million t of air cargo (DOS 1989). It should be mentioned here that, for the past decade, sea-air cargo has been successfully promoted. So has the operation of an efficient airport been crucial to the development of tourism in Singapore.

Land Transport

The land transport system of Singapore has seen so many improvements over the years. Coastal expressways-roads along the entire south coast of the main island (East Coast Parkway and West Coast Highway) form a major element of the overall road network (Fig. 4.6). The viaducts, Benjamin Sheares Bridge off the seafront of the city center and Marina Centre, which were completed at the beginning of the 1980s, provide a bypass for traffic to flow around, rather than through, the congested commercial center. Within the next decade, expressways will encircle the entire island.

The coastal roads pose an important presence on the coastal scene since they are formidable barriers to the movement of people. Unless underpasses and pedestrian-elevated walkways are constructed, it will be hazardous to attempt to cross these major roads. Even then, they still cut off easy access to the coast and cause a dislocation between the facilities and amenities that the residents can avail of from the coast and those activities that they can enjoy landward of these roads. The imposing flyovers also intrude into the land- and seascapes and may constitute an undesirable feature, although the view both of the ships and the city from these high structures is often spectacular.

A vital but intrusive form of coastal transport is the causeway. The 1.2 km-long Johor causeway was built in 1924 to carry road and railway lines as well as water pipelines. However, it completely severs the eastern and western parts of the strait, removing the possibility of navigating through the two sections. The construction of a second link, which will be a bridge across Johor Strait, has been under discussion for some years. An agreement has been reached, although details of its precise location as well as financial and other arrangements are as yet unavailable.

Since the causeway completely severs the eastern and western parts of the strait, it has also stopped the free flow of seawater through the strait, causing the buildup of stagnant bodies of water and the growth of pollutants. With the increase of urban areas and the rise of industries on both ends of the causeway, it becomes even more important to control pollution rendered more difficult by the presence of the causeway since it is likely to lead to the loss of options for other possible uses within the strait. Thus, the feasibility of opening up the causeway to enable the free flow of seawater through the strait should be examined; the cooperation of the neighboring states will certainly be encouraging. The environmental impacts of the construction of the causeways linking the mainland with P. Brani and P. Damar Laut (mentioned earlier) should also be looked into. Mention should be made here that, instead of a causeway, an undersea tunnel or a bridge would have been the better alternatives in spite of the additional costs involved. Moreover, if a mathematical model can be drawn to study the effects of coastal reclamations on the hydraulic regime (Yong et al. 1991), then it is assumed that a similar model showing the effects of causeways could also have been made prior to these causeways' construction.

Apart from the Johor causeway, a variety of transportation and communications facilities has been developed to link the island-nation to nearby land masses and the rest of the world. A system of ferries and for-hire boats facilitates the movement of passengers between the mainland and the offshore islands, the Riau Islands, as well as to points beyond. The Sentosa cable car system is a tourist attraction providing an aerial connection for people (Fig. 4.6).

Other connections in the form of undersea tunnels and pipelines extend the benefits from the major infrastructures and the socioeconomic system to the offshore islands. Undersea oil pipelines link SBMs to the oil refineries on the islands and the mainland. Water pipelines from Johor to Singapore are already in place, while the new gas pipelines from Peninsular Malaysia have been completed. For the future, water pipelines from Sumatra and gas pipelines from Natunas, Indonesia are envisaged.

Communications

Singapore's telecommunications facilities can be found on the seabed of the coastal area. They effectively break down the barrier of the sea, thus reducing the isolation of the island-nation. This worldwide telecommunications network forms the basis for developing the nation into a "global city".

A large number of submarine cables carry telephone lines connecting far-away destinations; others provide power and water. Fig. 4.6 shows that the main corridor for these communication cables is located to the east of Marina Centre on the western end of East Coast Park. The industrial plants in the Southern Islands are served by the submarine cables carrying power, communications as well as water pipelines to them. In Johor Strait, there are also

similar undersea cables (and pipelines) linked to the Malaysian Peninsula. To cope with the proliferation of underwater cables and pipelines, PSA is considering the establishment of a national integrated seabed tunnel system (Lim 1991).

MANUFACTURING INDUSTRIES

The first priority of a newly emergent nation is to find ways to develop its economy rapidly, create employment and ensure social stability. To achieve these objectives, Singapore embarked on an ambitious industrialization program.

The first priority of a newly emergent nation is to find ways to develop its economy rapidly, create employment and ensure social stability. To achieve these objectives, Singapore embarked on an ambitious industrialization program which included the development from the early 1960s of the Jurong Industrial Estate on the southwest coast (Fig. 4.8). As a result of these efforts, the total output of the manufacturing sector alone reached S\$55.5 billion and its value added, S\$17.6 billion in 1988 (DOS 1988). In fact, the sector accounted for the largest proportion of GDP (30.2%) and was ahead of the financial and business sectors (27.3%), commerce (18.4%) and transportation and communications (13.8%) for that same year.

Jurong, the largest and earliest planned industrial estate, and other heavy, medium and light industries have been located in the coast for two reasons. First, direct access to the sea is essential for export-oriented manufacturing industries in order to conveniently handle their overseas cargoes. Many of those located around the periphery of the port and the industrial complexes on the offshore islands have even developed their own cargo and passenger terminals. Second, the more pollutive industries, generally the heavy industries, were located on the coast away from commercial and industrial areas to control their industrial effluents from entering the water catchment areas, especially when many of the rivers have been impounded at their mouths (Fig. 4.8) to create reservoirs for drinking water.

Among the industries found in industrial estates situated near or along the waterfront are: power generation plants; oil refineries, petrochemicals and other oil-related industries; shipbuilding, repairing, rigbuilding and other marine industries; iron and steel mills and other heavy industries; sawmills; woodworking factories; flour- and feedmilling; cement making; and others (Fig. 4.9). Since these industries generate wastewater that eventually enters the marine environment and adversely affects it, it is relevant to study these industries' CAM Programs.

Petroleum Industries

Singapore is a major center for oil distribution and a bunkering port. Its oil refineries can process over one million barrels per day (bpd). This includes the secondary refining of oil products. Each oil complex also possesses a very large storage capacity for crude oil and crude oil products. Of these oil products, only a tenth is consumed domestically, while the rest is sold either as aviation or bunker fuel to ships calling at the port. Of the total tonnage of cargoes handled at the port, some 60% is mineral oil-in-bulk which generates a very large demand for shipping services from crude and product tankers as well as large and small liquid gas carriers.

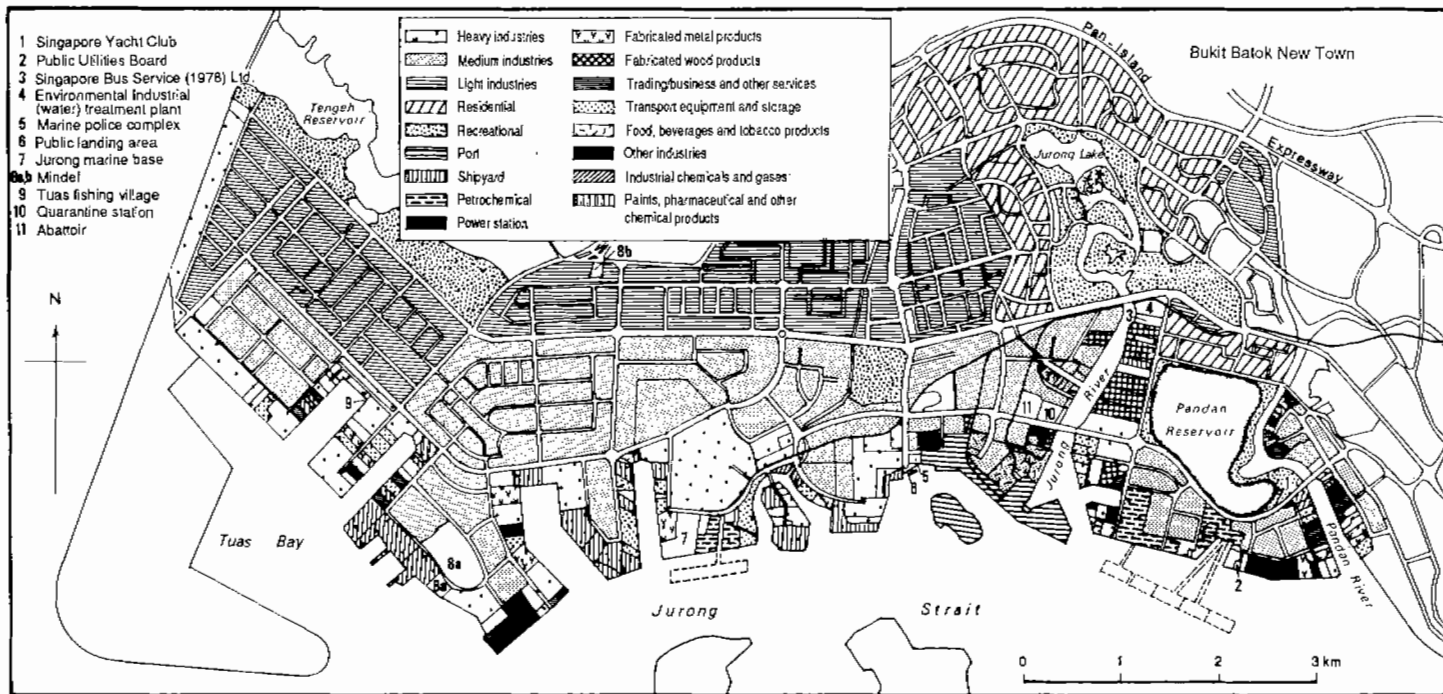


Fig. 4.8. Singapore: Jurong Town and waterfront industries.

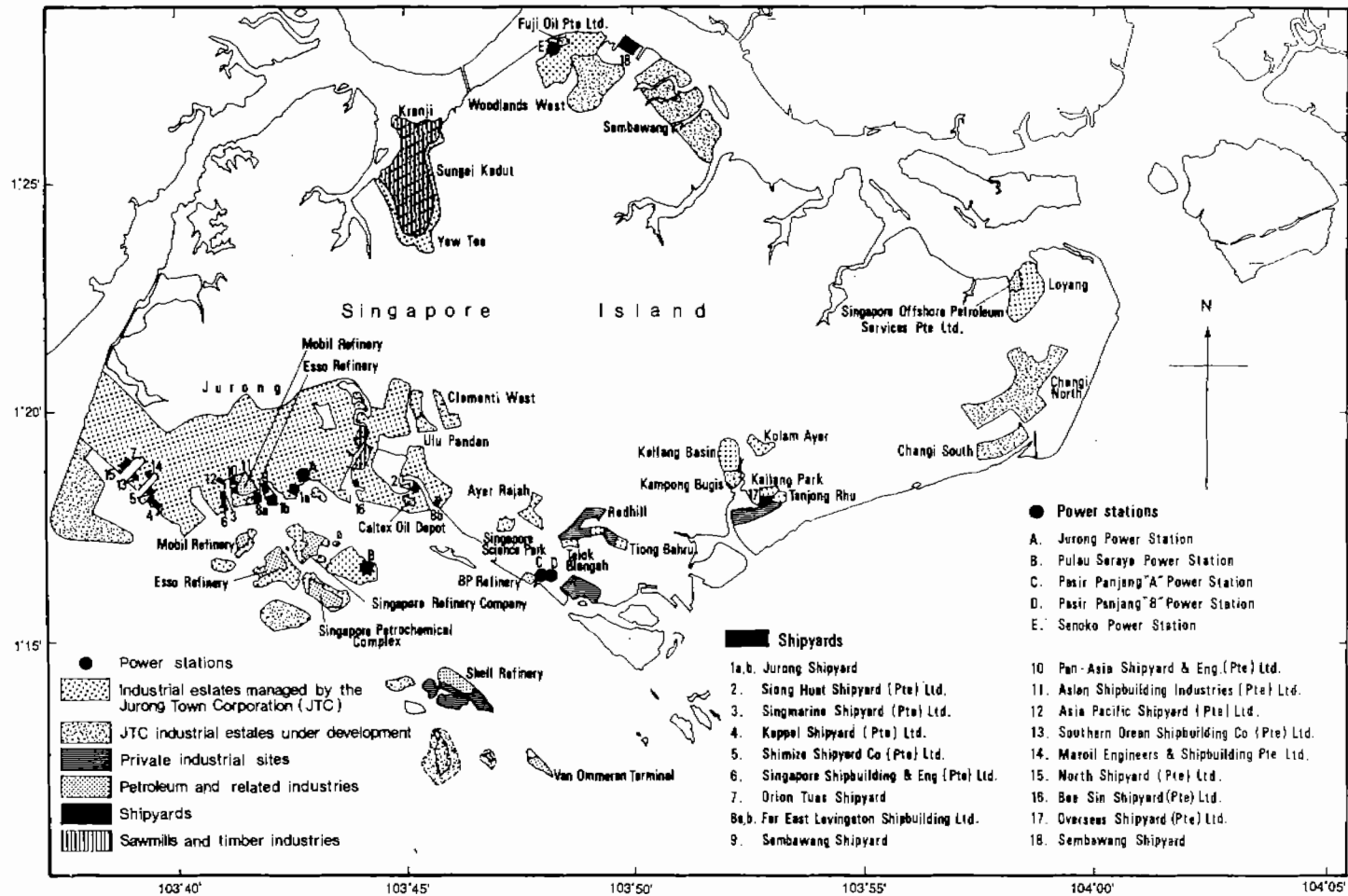


Fig. 4.9. Singapore: manufacturing industries and power generation plants.

The petroleum manufacturing and related facilities are located mainly on the offshore islands to keep these major sources of air and water pollution away from the main island. However, several of the facilities are separated from the main cluster of industrial islands and spread out in a group of islands around P. Semakau where the waters contain the best coral and marine life. These islands have been earmarked for industrial development; P. Bukom has long been used for Shell's refinery complex. The presence of these facilities and the movement of tankers loaded with crude oil, petroleum and derived products pose a heavy threat to the marine environment, although the mobility of the seawater renders the threat a fairly general one for the entire coastal area, especially within the southern waters of Singapore. Moreover, there are four downstream plants producing a range of plastics and other products. Also, there are two major companies operating large oil and chemical storage facilities, with a third recently established in the country.

While PCS was commissioned in 1984 to oversee the operation of the petroleum industries and PSA has its OSTC on P. Sebarok for treating the waste oil discharged by the ships, it is essential for all to be vigilant in preventing the pollution of the coastal waters by (1) avoiding the accidental spillage of toxic substances and (2) adopting effective treatment methods to remove the toxic and pollutive substances from the wastewater before releasing them into the sea. The large fire in November 1988 in one of the refineries on one of the islands within the Southern Islands group illustrates the need to devise ways to cope with the accidental discharge of large quantities of oil substances into the marine environment. Tan (1991) reported on the method used by Shell refineries on P. Bukom. Generally, oil refineries have their own system of sludge and wastewater treatment and air pollution control. It is also important to reduce thermal pollution because of the high sensitivity of marine life to slight increases in the water temperature. This is particularly important for the stagnant waters in Johor Strait.

Marine Industries

Singapore's marine industry dates back to many years ago. The dry docking facilities for ships in Keppel Harbour came about in the middle of the last century. In the early 1960s, the industrialization program was launched which promoted the marine industries and involved direct government participation in operating large shipyards, e.g., Sembawang and Jurong. Today, there are a total of 70 large and small shipyards, making Singapore one of the major shipbuilding, rigbuilding and shiprepairing centers in the world. Revenue from this industry grossed over S\$1 billion in 1978, reached S\$2.4 billion in 1981, but took a steep fall after 1982, recovering strongly only in 1987 and has since continued to grow.

Fig. 4.9 shows the distribution of the shipyards. Most of them are located along the Jurong coast. The small shipyards that used to operate out of Kallang Basin have either ceased operations altogether or moved to Tuas and Sembawang. Only one medium-sized yard remains but this will soon be

relocated too. The removal of these shipyards from Kallang Basin is in line with the country's improvement of its coastal environment since they generate pollution in the water when their bilge is cleaned out and when marine paint which contains lead is used on the ships. Moreover, the clustering of these activities has the advantage of making the control of water pollution more manageable. Thus, the existence of a large shipyard and a refinery in the Keppel area is a historical one, and creates conflicts with other more recently introduced coastal uses in the vicinity.

Other Marine-dependent Industries

Other industries that are dependent on the location and the use of marine resources have likewise been located on the waterfront. These include: the power generation plants in Jurong, Senoko and on P. Seraya off Jurong coast (Fig. 4.9); the iron and steel mills as well as the other heavy industries and factories requiring bulk-handling facilities such as flour mills, feedmills and cement manufacturing along the Jurong waterfront and around the perimeter of Keppel Harbour; and the sawmills and woodworking industries at the Kranji Industrial Estate and along Jurong River.

These waterfront industrial estates command a premium on their rentals because of the advantages presented by their locations. But, at the same time, the logs left floating on the water release their sap and tannin. The burning of sawdust and wood chips can cause severe air pollution. Malaysia and Indonesia have banned the export of logs, considerably reducing the activity of sawmillers. Sawmills along Jurong River have been relocated to Kranji as they are no longer compatible with the developments in the vicinity of Jurong River. Also, a mail survey was conducted to look into the use of the waterfront location by ships for loading and unloading, the use of seawater for recreation, and the disposal of wastewater and other materials.

COMMERCIAL USES

Additional foreshore reclamations along the coast off the Central Business District have effectively moved the coastline away from the existing population and commercial areas.

The CBD is located south of the main island around the mouth of Singapore River (Fig. 4.10). A part of the original CBD, previously known as the Commercial Square, was built on reclaimed land. Additional foreshore reclamations along the coast off CBD have effectively moved the coastline away from the existing population and commercial areas. Fig. 4.11 shows details of the waterfront land use of CBD, stretching from the Tanjong Pagar Container Terminal to Kallang River. Recent developments have also taken place on the newly created land in Marina Centre, while roads and basic infrastructures are beginning to be laid down in Marina East and Marina South. This land enables the city to expand without tearing down the historic parts of old Singapore in line with the conservation program of URA.

Land use along the Central Area waterfront reflects the traditional entrepôt role of Singapore. Here, large concentrations of banking, financial and insurance institutions; trading companies, including large well-established multinational firms, trade associations and small entrepôt-type businesses handling regional produce; professional businesses; restaurants; and retail

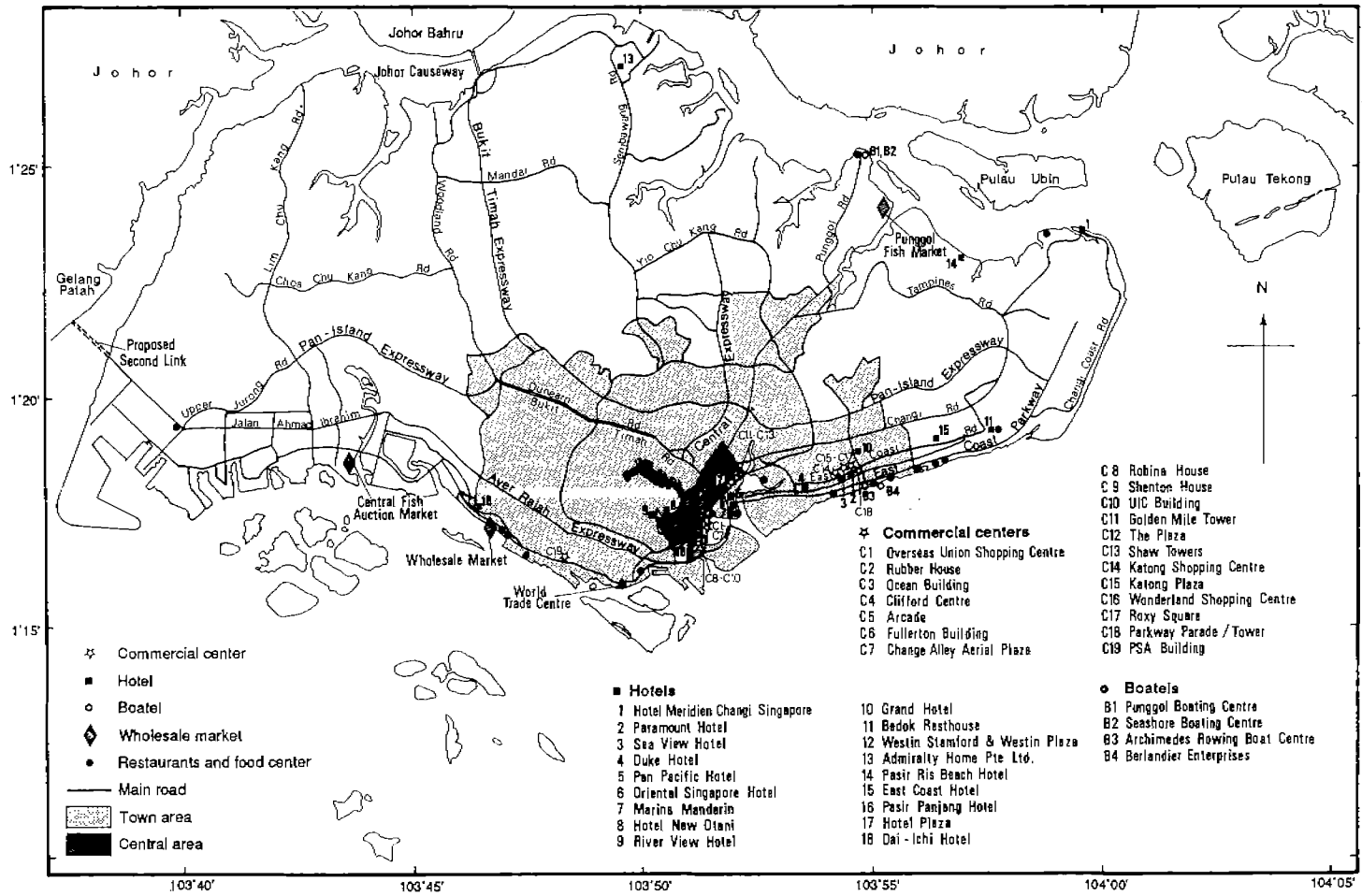


Fig. 4.10. Singapore: urban areas and commercial land use.

Chapter 4. Coastal Resources Uses

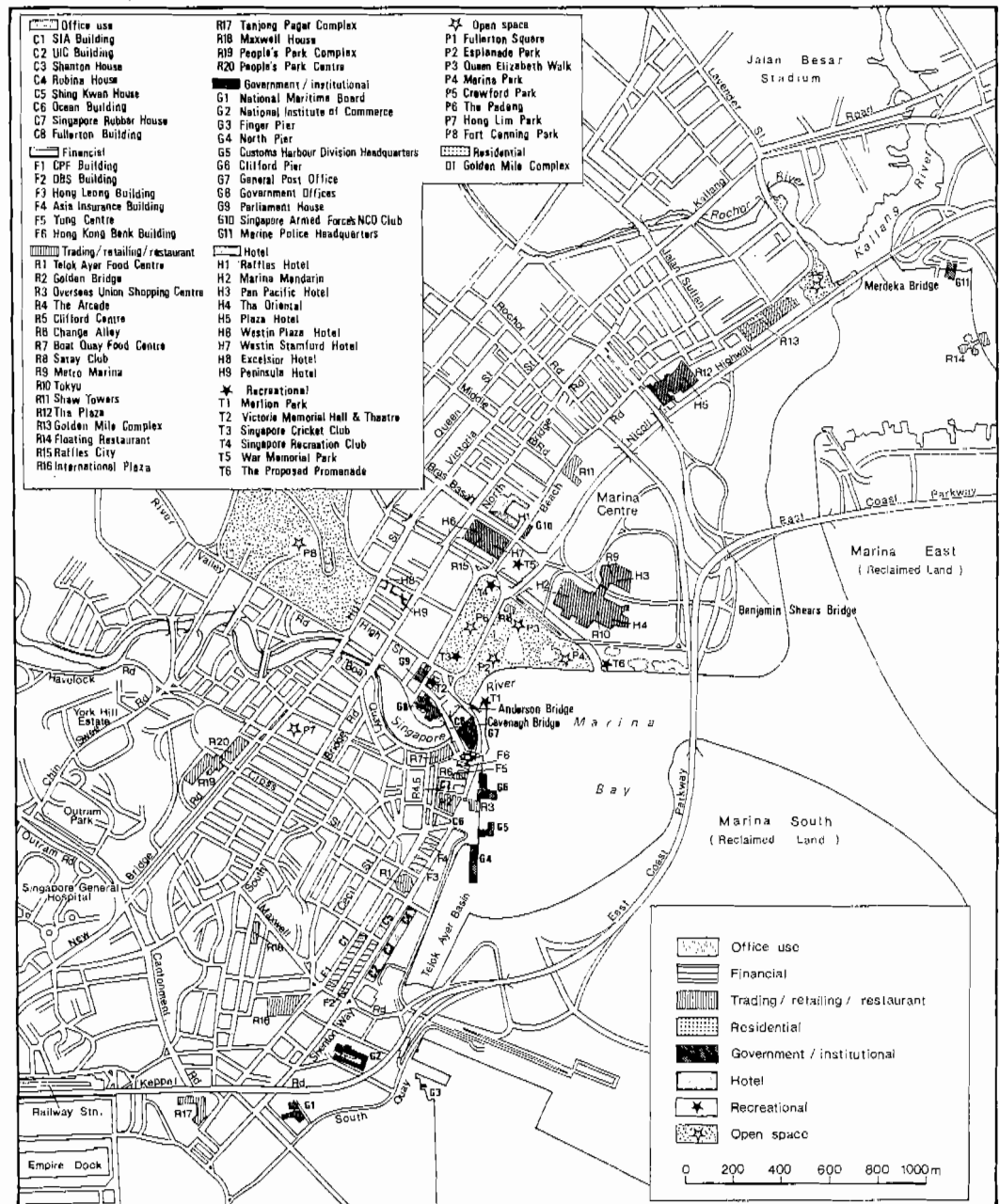


Fig. 4.11. Singapore: waterfront development in the Central Area and Marina Centre.

establishments are housed in modern office blocks and complexes. The upper levels of some of the high-rise buildings are used for residential purposes with the intention of injecting life after dark within the CBD environment. The older traditional Chinese two- to four-storey "shophouses" with businesses at street level and storage and sleeping quarters upstairs are found further inland. Many blocks of these shophouses have been demolished to give way to the modern high-rise buildings along streets nearer the

seafront, e.g., Cecil and Phillip Streets. While many small hotels remain in old Singapore, several modern large ones have been built in Marina Centre. In the late 1960s, URA also initiated the development of the so-called "Golden Mile" along Beach Road to the east of CBD (see Fig. 4.11), although commercial development has tended to gravitate towards the Orchard Road corridor.

Marina City

The development of Marina Centre has been going on since the early 1980s, using a system of land sales to entice private developers to invest. Today, it forms the seaward extension of the Orchard Road commercial axis and is reinforced by the opening of the mass rapid transit system along this axis. Planned as a mixed-use development center, it will consist of hotels, shopping malls, restaurants, offices, residential areas, recreational facilities and open spaces (Fig. 4.11). So far, Raffles City and Marina City's several thousand-room hotels and shopping complexes have been completed.

A recent publication of URA (1989) shows that the entire waterfront of CBD will be comprehensively redeveloped. The plan includes the development of Marina Bay and Kallang Basin as well as Singapore River to represent "a comprehensive plan for developing Singapore's three water assets." Of considerable interest is the emphasis on developing recreational, shopping and restaurant facilities which "will provide an exciting experience for the visitors." Among other marine-related elements, the plan suggests developing sandy beaches and parks, mooring and harbor craft activities and providing better access to the waterfront and a continuous pedestrian promenade around the bay. It also calls for the creation of a large urban playground on land and in water in the heart of downtown Singapore, the removal of conflicting land uses, and the maintenance of a generally low-rise waterfront development in order to define the water edge's profile and to capture the ambience for waterfront activities. All in all, the plan hopes to concretize the image of a truly tropical maritime city which is indeed an exciting development which all Singaporeans will look forward to in the next few decades.

East Coast

As mentioned earlier, commercial development along the coast of the main island has been set back from the waterfront by newer land uses for the reclaimed land. Such is the case in the East Coast Road development comprising Katong, Bedok and Siglap which fall inland of East Coast Park. Fig. 4.12 shows details of both the park and its land uses. The Katong and Joo Chiat commercial center may be regarded as comprising a major suburban center with a high degree of self-sufficiency in public and commercial services and recreational facilities. There are also several modern hotels and many small Chinese-style hotels in the vicinity. With the development of public housing at Marine Parade, the large new towns of Bedok and Tampines farther east as well as the private apartments and condominiums

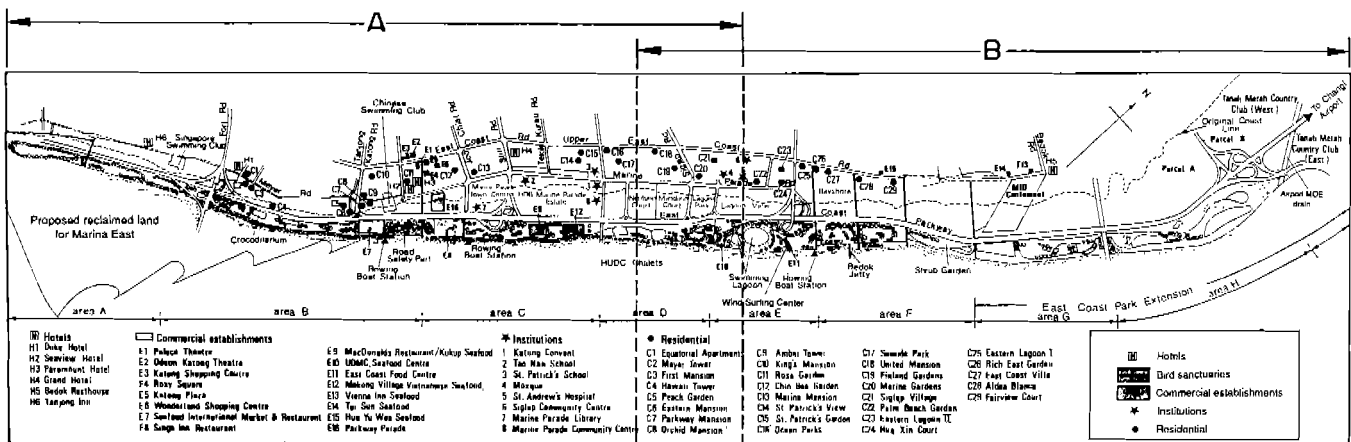


Fig. 4.12. Singapore: East Coast Park and adjacent developments (see Fig. 4.12a and 4.12b for an enlarged version of map).

in the Katong area and along Marine Parade Road, the hinterland will soon be provided with a commercial center, too.

Further towards the east, Changi Airport truncates commercial and housing developments until close to Changi Point on the eastern tip of the island. Within Changi Airport itself, the catering services of the Singapore Air Transport Services (SATS) and Changi International Air Services (CIAS) as well as the many freight forwarding agents housed in separate buildings comprise important commercial establishments. Within Changi Village, this modern rebuilt village has a new hotel and shopping and residential blocks. These establishments serve vacationers and visitors to Changi Park and to the government holiday chalet complex at Changi and Fairy Point.

West Coast

Along the southwest coast, the port complex takes up almost the entire stretch of the coastal land from CBD through Keppel Road and Pasir Panjang on the original coastline and the reclaimed land. The only exceptions are the Keppel Shipyard, BP refinery (to be decommissioned) and the adjacent Labrador Park between the Keppel and Pasir Panjang wharves. WTC, owned by PSA, forms the main commercial focus. Tanjong Pagar Complex and farther west, scattered small commercial establishments along Keppel Road are blocked off from the waterfront by the ports. However, the Fruit and Vegetable Wholesale Centre and a cluster of restaurants at the western end of the Pasir Panjang Wharves have access to the waterfront. Finally, although found at some distance from the waterfront, there are small commercial and food centers and restaurants within Clementi South which is part of Clementi New Town, a public housing estate.

Chapter 4. Coastal Resources Uses

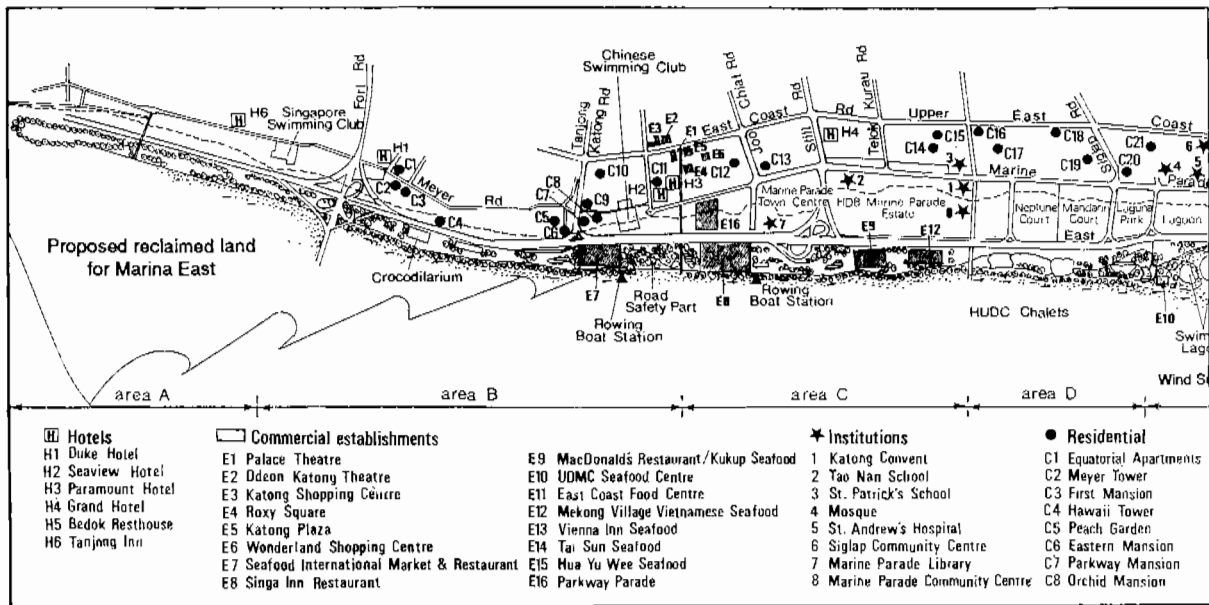


Fig. 4.12a.

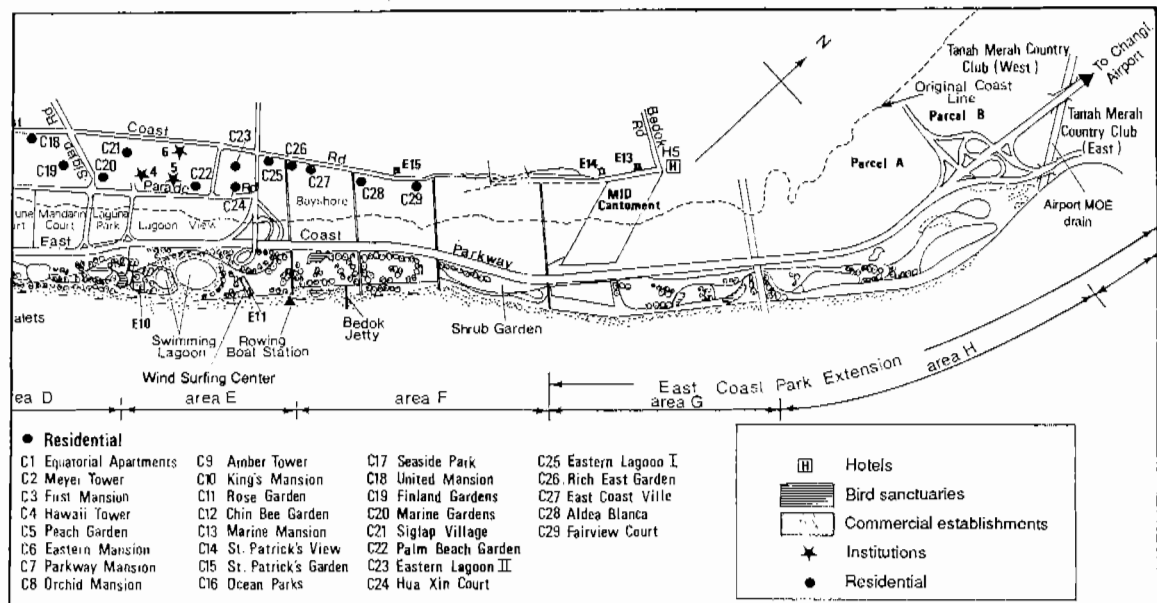


Fig. 4.12b.

Other Areas

The only cluster of commercial developments on the swampy and mangrove-fringed northern coast of the main island is the group of seafood restaurants and sundry shops at Punggol jetty. The commercial centers are found within Woodlands New Town which is near the Johor causeway. Access to the waterfront along Johor Strait is cut off by the Sembawang port and shipyard and the Senoko Power Generation Plant. Plans for the Pasir Ris New Town, currently under construction, provide for commercial (town and neighborhood) centers which are closely accessible to the Pasir Ris Park on the waterfront. Then, there is the small town center on P. Ubin which consists of the usual assembly of restaurants, sundry shops and hairdressing saloons. On P. Sakeng (or Saking), the other inhabited island, there are several shops catering to the needs of the islanders and visitors. A similar township on P. Tekong has disappeared with the land acquisition and conversion of the island into a military training camp.

TOURISM AND RECREATION

There are two types of tourist and recreational facilities: those publicly developed and operated and those which are privately developed (Fig. 4.13). Most facilities cater to both tourists and the local residents for recreation. Public coastal facilities include the parks and open spaces on Sentosa and other offshore islands, while the special facilities are those found on Sentosa Island and the main island. Private commercial facilities include recreation clubs and associations (some are privately owned; by membership only) and the sporting and recreational facilities on the coastal parks leased from the government.

Public Facilities

Through the Parks and Recreation Department (PRD), the Sentosa Development Corporation (SDC), the Singapore Tourist Promotion Board (STPB) and other development agencies, the government has developed a series of parks—large-sized on the national level, medium-sized on the regional level and small-sized on the urban and local levels (Fig. 4.13). These are in addition to the private parks and the nature reserves. In this undertaking, the government aims to provide a ratio of 0.8 ha of open space per 1,000 population (Fung 1991). This has been confirmed in the details released by the revised Concept Plan (URA 1991).

The largest coastal park is the 206-ha, 13 km-long East Coast Park (Fig. 4.12). It has a wide range of commercially operated recreational facilities and food outlets on leased land, a swimming lagoon, a holiday chalet complex operated by the national labor union, a People's Association (PA) holiday camp and a seafood center. It is the most heavily utilized park, catering to a large number of visitors and a wide range of marine sporting activities, including fishing, canoeing and wind surfing. Other coastal parks, like the Labrador, West Coast and Pasir Ris Parks, are smaller but there are plans for their development. Facilities typical of these parks are washrooms, kiosks, bicycle and jogging paths, exercise facilities, barbeque pits and waste bins.

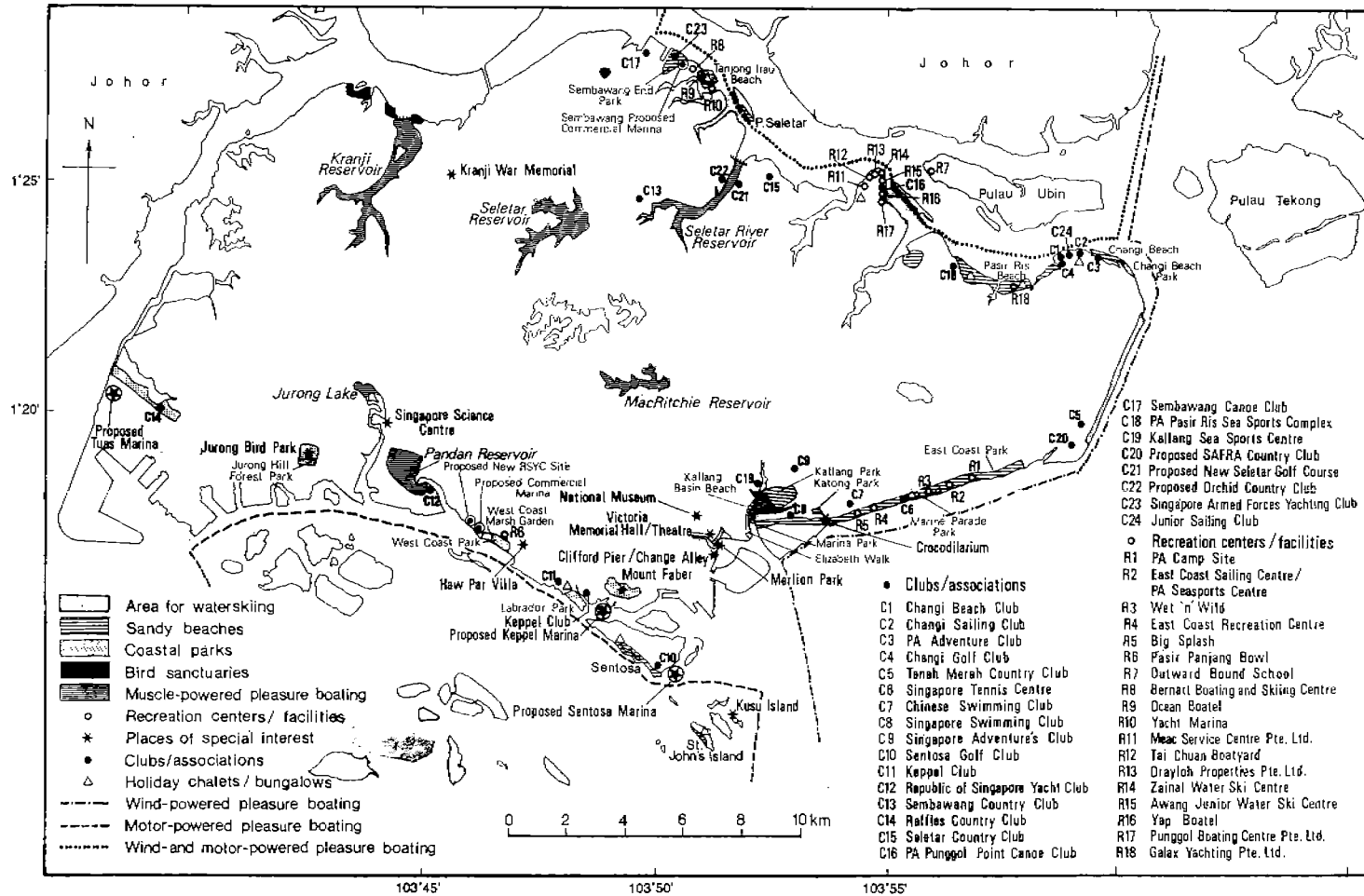


Fig. 4.13. Singapore: recreation and tourism.

As for the one true nature reserve, the Bukit Timah Forest Reserve, it has a relatively undisturbed vegetation which serves as the central catchment area for the reservoirs. Because of urban expansion, which earlier removed other nature reserves, even the Bukit Timah is no longer sacrosanct. The only coastal nature reserve, Labrador Park, lies west of Keppel Wharves, although there are still patches of forested land on Sentosa, P. Ubin and P. Tekong Besar, and on parts of Kent Ridge and Lim Chu Kang on the main island.

Offshore Islands

P. Ubin, which represents the largest tract of undeveloped area accessible to the public for recreation, remains an interesting case study for CRM.

Sentosa Island has been developed as the largest tourist facility with a range of attractions including an elaborate ferry terminal building, butterfly park, the Surrender Chamber, Fort Siloso, the Corallarium, a swimming lagoon, golfing range, holiday chalets, a monorail system and bus services to bring visitors around. The Maritime Museum, owned by PSA, houses a fine collection of exhibits. More attractions along the lines of theme parks are being planned and developed (see Fig. 4.14). The island, which is linked to the mainland by a ferry service and the cable car system, will become much more accessible with the completion of the causeway. Recently, the planned rail-based people mover has been shelved because of the escalation of costs in building the facility.

A number of islands which belong to the Southern Islands group is also under the responsibility of SDC for the development of their tourist and recreational facilities. The most accessible (by ferry) and the best developed (much like the coastal parks) is St. John's Island. Kusu Island provides an unusual attraction during the months of October/November when hordes of people swarm the island to worship at a Chinese temple and a *kramat* as part of a religious festival (Fig. 4.13). As mentioned earlier, the inhabited island of P. Sakeng also attracts tourists who visit the *kampung laut* (sea village). However, since the island was earmarked for "development", most of the able-bodied people have left for the main island to work, leaving behind old people with some children in rundown houses on the badly neglected island.

The other inhabited island of P. Ubin represents the largest tract of undeveloped area accessible to the public for recreation. It remains an interesting case study for CRM in terms of identifying existing resources and activities on the island and managing them for the greatest benefit. A preliminary survey undertaken by the CRMP team shows the land use of the island (Fig. 6.2) which is underlain by granite and has steep slopes around the hills. It is served by a system of metalled roads and footpaths. There are a number of jetties, too, which may be reached by launches (ferries) from Changi Point and Punggol jetty on the main island. Some are owned by the granite quarry operators. Part of the island is forested while there are fairly large tracts of swamps with mangroves and nipa in them. There are one large and many small shrimp ponds, fruit trees and a few patches of vegetable gardens.

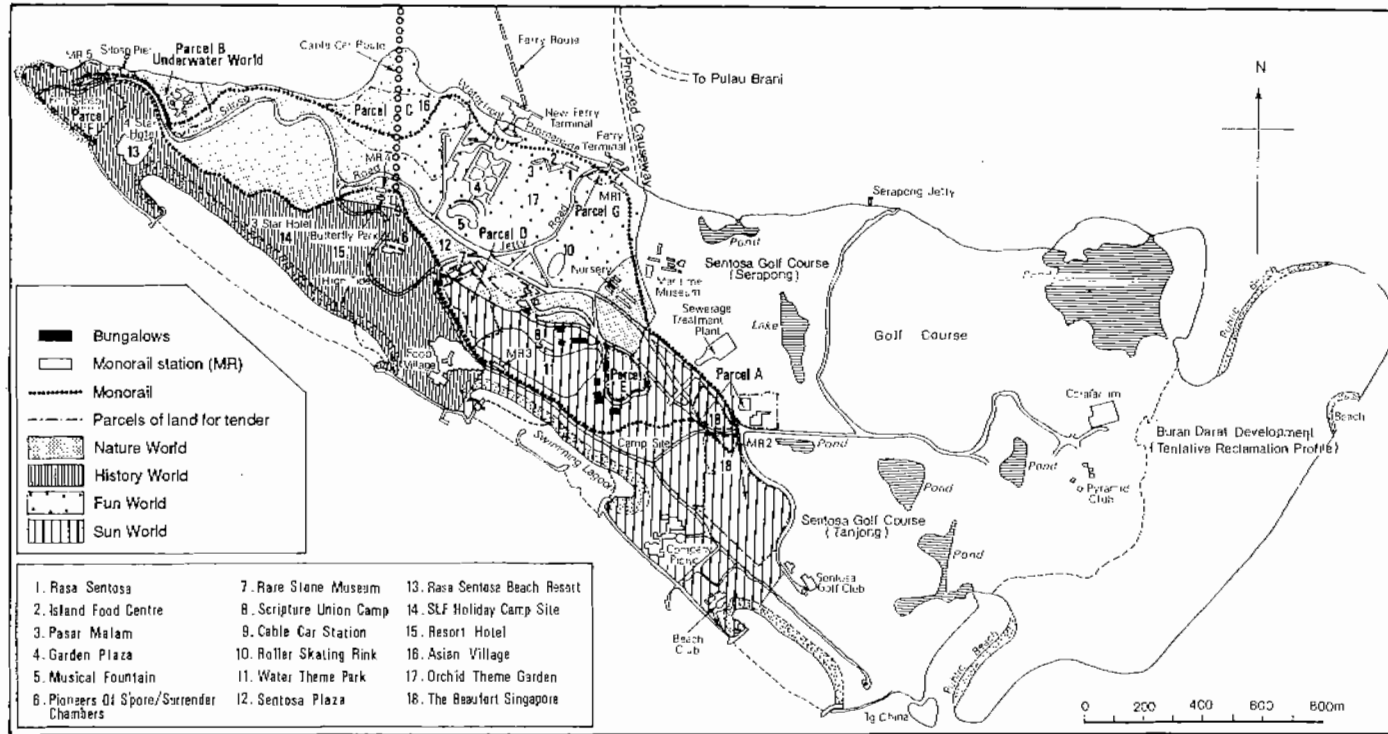


Fig. 4.14. Singapore: Sentosa Island.

Based on the 1980 census, the island had a population of 1,242. Fishing is still practiced by the islanders, although not as the sole means of livelihood since many of the able-bodied now commute to and from the main island where they work. Also, many of the families left behind are in the process of moving out permanently. Apart from the village center, there are several *kampung*. The island, which has been used as a political detention center, has three camp sites. Two are run by the Singapore Outward Bound School (SOBS); the other, by PA which also has a privately operated holiday chalet. The island has a sufficient supply of freshwater and electricity and even has telephone lines.

The rugged terrain, natural vegetation and abundant birdlife thus offer interesting recreation potentials for the island. It came as no surprise then when the announcement of plans to expand SOBS on the western end of the island raised fears that the island may suffer the worst consequences of "development" and lead to the loss of its ambience and natural beauty since the revised Concept Plan envisages the island as an "open space/recreational locale", albeit only up to the year 2010. Beyond that, parts of the island and those on the neighboring P. Tekong will be used for residential and institutional purposes and be linked by a high-capacity transport system for it is expected that the number of people in Singapore will reach 4 million then and thus can no longer be accommodated on the main island (URA 1991; Fig. 4.2).

There are at present no marine parks in Singapore. However, this did not deter RSYC, SIB and SUF with the support of SSLC and the National Council on the Environment from submitting a proposal asking for the effective conservation of the coral reefs in four areas: (1) around P. Hantu, Terumbu Pempang (T.P.) Laut, T.P. Tengah, and T.P. Darat; (2) Sisters Islands, St. John's Island, Lazarus Island, Kusu Island and P. Seringat; P. Semakau and the reefs to the west of it; and (4) P. Sudong, P. Pawai, P. Senang and P. Biola which is currently a protected zone used for live-firing exercises (Fig. 6.1). Details of this proposal will be further elaborated on in a subsequent chapter.

DEFENSE AND SECURITY

Several coastal sites and offshore islands are used for defense purposes.

Several coastal sites and offshore islands are used for defense purposes. Mention has already been made of the use of P. Tekong Besar as a military training camp. P. Senang was previously used as a penal camp but, together with P. Pawai and the surrounding waters, they are used as live-firing zones for bombing practices. P. Brani serves as a naval facility, thus, the water between it and Sentosa is off limits to the public. The seaspace near the military camps along the northwest coast are used for naval exercises, thus, it is also restricted. While the marine police plays an essential role in the control of smugglers and other illegal activities at sea and a surveillance system is followed when using the patrol boats, there continue to be many unreported cases of piracy on merchant ships, albeit on the outer fringes of Singapore's territorial waters and beyond, and reported cases of their intrusion onto the main island through East Coast Park.

AGRICULTURE

In the intense development of the whole coastal area of Singapore, there have only been little extensive forms of activities.

In the intense development of the whole coastal area of Singapore, there have only been little extensive forms of activities. The decline of the domestic capture fisheries attests to this. The dominant use of the seaspace for shipping and port operations purposes preempts it from commercial fishing purposes. Also, areas that are reserved for defense purposes are similarly off limits to fishing. In addition, the poor quality of the waters around the industrial areas similarly precludes the possibility of reasonable fishing. The country has, therefore, to turn to intensive aquaculture, utilizing waters unaffected by the above-mentioned activities to best use the remaining seaspace's resources.

Marine Fisheries

Out of a total of 516 fishing vessels, 460 are powered and the rest are non-powered. In 1983, licensed fishermen totalled 1,641. In 1984, the corresponding numbers were 769 fishing vessels, 509 of them powered and 2,194 licensed fishermen (DOS 1983). Local fish production, defined as catch by the locally registered vessels, came to about 25,000 t in 1984 from a low of 14,000 t in 1977. Catch by *kelong* also declined. There is little known about the local fishermen, but most of them would be part-time rather than full-time. Some continue to go out on powered *sampan* (local craft now increasingly rare) to fish, using throw nets and hook-and-line methods, depending on the fish species being pursued. Others use throw or push nets in the shallow waters along the coast. There have been reports of trawlers, presumably both local and foreign-registered, operating in Singapore's waters, but there are no restrictions on trawl fishing, except in areas designated as protected waters for defense or security purposes.

Aquaculture

Freshwater and brackishwater aquaculture involving the operation of shrimp- and fishponds has declined since it peaked in the 1950s. The conversion of these ponds by the government into more intensive forms of land use through land reclamation and the acquisition of land for industrial and other purposes have been the main reasons for their decline. In any case, these ponds have become progressively less productive and economical to operate because of the high labor costs, silting and other problems. PPD has designated several areas in the northern coastal portions of the main island and on P. Ubin as agrotechnology parks (Fig. 4.15). Encouragement is given to promote high-technology fishfarming using such methods as raceways for the intensive stocking of shrimp as well as the production of freshwater ornamental fish. The export of the latter reached a total value of \$51.7 million in 1986, while total aquaculture production was 1,490 t. This represented only 1.3% of the total fish supply which was well short of the 10% targetted for 1995. On the other hand, freshwater finfish aquaculture, which includes such fish species as the silver, grass, bighead and puntius carp, the marble goby, the red tilapia and the snakehead fish, accounted for 200 t (13.4%) of total production. It is expected that production will rapidly increase in the future.

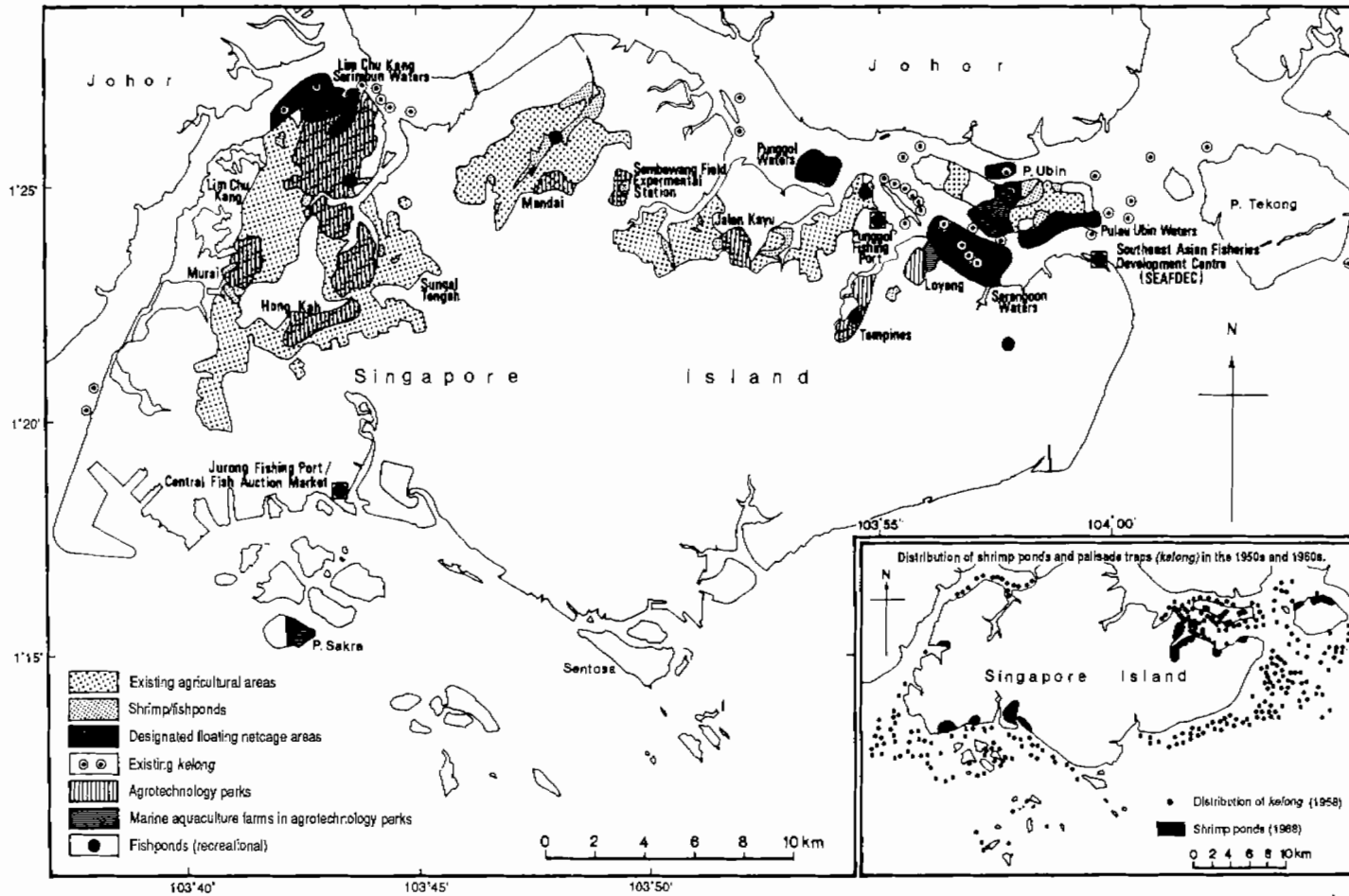


Fig. 4.15. Singapore: agriculture and fishing.

Marine fishfarming began in 1970. With the encouragement and technical support of MAS of PPD, many more have taken it up as a commercial venture. In the East and West Johor Straits (Fig. 4.15), 100 ha of seaspace were set aside and designated for the operation of floating fishfarms. In mid-1988, there were 66 such farms operating in these areas, especially to the south of P. Ubin. Finfish which are currently being cultivated include the seabass, groupers, snappers, siganids, golden trevally and yellowfin jack. In addition, the mangrove crabs, banana shrimp and spiny lobster are being cultivated, while the green mussel is cultured on ropes suspended from rafts (Cheong 1988).

Other Agricultural Forms

Market gardening which involves the growing of fruits and vegetables, the rearing of poultry, duck and livestock, and fishfarming are undertaken mainly in the northern portions of the main island and on P. Ubin. The areas devoted to farming (Fig. 4.15), including those still under old unproductive rubber trees, have shrunk rapidly over the last few decades as a result of the expansion of built-up areas in response to rapid economic and social development and the deliberate planning that has taken place (see various Master Plans which have been updated once every five years since 1965). Thus, the development of intensive high-technology farming in the designated areas (Fig. 4.15) earlier mentioned will form the basis of farming, including horticulture, for the future.

To supply the much needed potable water for domestic, commercial, industrial and other purposes, many of the main rivers were impounded at their mouths since the 1960s in order to serve as reservoirs. Large parts of the main island were also converted into catchment areas for the reservoirs. To control the pollutive forms of farming, specifically pig and duck farming, these were progressively removed from the catchment areas.

Earlier, pig farming was taken from such areas as Kranji, Lim Chu Kang and Chua Chu Kang and concentrated at the Punggol Peninsula in the northwest where farmers were required to construct wastewater treatment plants to dispose of the large quantities of their pigs' wastes. However, the continued pollution of the water courses and Johor Strait and the expansion of the catchment areas for the coastal reservoirs (Fig. 5.1) prompted the government to decide to phase out pig farming completely from the main island by 1990 and to enlarge a small island, P. Terembu, in order to serve as a holding station for imported pigs.

MARINE SCIENCE AND EDUCATION

The Hydrographic Department of PSA, the Marine Fisheries and Marine Aquaculture sections of PPD, together with the staff of the Departments of Geography, Botany and Zoology of NUS represent the key scientific capability of marine science. Chia and Chou (1991) reported on the courses and programs related to CRM offered by NUS. The Southeast Asian Fisheries

Truly, much has to be done to instill greater overall public awareness and interest in the wide variety and awesome beauty of marine ecology.

Development Centre (SEAFDEC) located in the Marine Fisheries Complex at Changi Point provides additional capability as do the Singapore Science Centre and MNS (Singapore branch). Despite all these organizations, there is as yet inadequate understanding of the marine environment and resources (Chou and Chia 1991). Several major research efforts, including the ASEAN/US CRMP and the ASEAN/Australia Coastal Living Resources Project, promise to fill some gaps in the body of information so far acquired.

Coral reefs and marine life have always interested fishermen and divers. Further interest in the marine environment will be generated by the Undersea World Sentosa, which began operation in 1991 (Newman 1991), and the possibility of doing research in its laboratory and using its other facilities is realized. MNS is also developing an undersea trail to promote scientific and public interests. A small patch of mangroves near the mouth of the Seletar Reservoir has been preserved as a feature of the reservoir park. Truly, much has to be done to instill greater overall public awareness and interest in the wide variety and awesome beauty of marine ecology.

CHAPTER 5

COASTAL AREA MANAGEMENT ISSUES

The present chapter brings together the issues related to CAM with special reference to Singapore. It discusses the various coastal users and their associated activities and indicates some of the problems and needs requiring a broad-based management strategy. The final chapter that follows will seek to explore the approaches and strategies that can be adopted to help resolve these issues to bring about the better management of these limited resources and thus derive the maximum value arising from their use.

A growing number of CAM schemes have been developed in the United States and other advanced countries as a response to the often intense pressures arising from activities involving large-scale industries, housing and tourist or leisure projects, seaport improvements and land-filled foreshore areas. Since achieving self-rule in 1959, Singapore's urgent development for quick economic gain has taken precedence over environmental issues, although the need to conserve, protect and enhance the environment has increasingly come to the fore as far back as the late 1960s. In the 1980s, emphasis on environmental and nature conservation was given new impetus, especially in keeping with its status as a developed nation. Not only has historic Singapore been conserved, but its physical/natural environment has also been enhanced. In 1989, URA took on the responsibility as the national conservation authority to preserve and manage the historic sections of Singapore, while the National Parks Board (NPB) was created to look after the Central Catchment Area and the nature reserves. In 1991, MOE declared that Singapore should strive to become an "environmental city" in the national leadership's desire to further improve the quality of life for Singaporeans through cultural enrichment and a more conducive human environment.

Of more immediate concern is that the waterfront land and the surrounding waters have been subjected to strong and sustained disturbances from a whole series of activities connected with the implementation of development projects within them.

While the whole of Singapore can be considered to be coastal in nature to the extent that physical changes even in inland locations can have an impact on the coastal environment, of more immediate concern, however, is that the waterfront land and the surrounding waters have been subjected to strong and sustained disturbances from a whole series of activities connected with the implementation of development projects within them. There has as yet been only minimal effort in protecting and conserving the limited but valuable coastal resources, although there are good indications that this situation

is changing (Goh 1991; Lim 1991; Mattar 1991). Albeit, it is likely that developmental needs rather than environmental concerns will continue to take precedence for the time being.

The 1991 revised Concept Plan has given strong emphasis to the physical and aesthetic aspects of the environment with the implementation of the "Blue and Green Plan" (URA 1991), but it is not certain how much consideration will be given to the protection of the natural environment through the use of sound ecological principles. Massive reclamations to gain more land from the sea will inexorably continue to alter the coastal and island environment. There may be no alternatives but to develop P. Ubin and P. Tekong intensively for recreational, residential and industrial uses should the population approach the 4 million level (*Straits Times*, 10 January 1991 issue). The only remaining option is to plan for the comprehensive and rational use of all coastal resources on a balanced, integrated and multisectoral basis.

The earlier discussion on the various coastal resources uses has indicated in several places the conflicts and problems that have already arisen. They have come about in part because of the narrow unisectoral or single-agency approach that has basically shaped the direction of the changes affecting the coastal environment and the way coastal resources have been allocated for specific uses. As a first step towards a holistic management approach, it is useful to identify these problems by constructing a conflict matrix among coastal resources, on the one hand, and on the other, the various coastal development uses. This will enable an examination of the interaction between each pair of resources/uses and the identification of the points of conflict between them. In this way, the nature and cause of the conflicts may be better understood and point to the possible directions for their resolution. The multiple-use principal on a long-term sustainable basis can then be applied to augment the returns from the use of all coastal resources.

CONFLICTS AMONG COASTAL RESOURCES USES

Marine pollution and the degradation of the coastal environment lie at the heart of the conflicts among various uses.

Conflicts among the various coastal resources uses may have been exacerbated in the process of change and the insufficient attention paid to redressing the problems generated. In general, the issues have arisen as a result of the displacement of earlier uses by more recent developments along the coast of the main and offshore islands as well as over the territorial waters. In many ways, these issues may be regarded as fairly broad and applicable not only to coastal resources use but also to the use of the land for the whole of Singapore. Some of the changes have been deliberately brought about through comprehensive social, economic and physical planning, as exemplified by the development of the Long-range Concept Plan, in the interest of the nation.

There have obviously been adverse consequences and reactions, but the perceived benefits of increased income and improved quality of life appear to have more than compensated for the negative impacts. Still, a detailed analysis will be necessary to properly assess the full extent of the total long-term costs involved, as in the case of the industrial projects on the offshore islands which necessitated land fillings and, as a consequence, destroyed the surrounding coral reefs, polluted the marine environment and damaged the seabed. As opposed to these, if the natural resources were conserved, then the value to be generated from their recreational, tourist and educational/scientific uses can be enjoyed by very large numbers of people over the long term. The general public, to a large extent, has learned to accept the consequences of these changes, both negative and positive, as the inevitable spillovers of rapid development, an evidence of the Singaporeans' increased awareness of their environment, greater understanding of its value, and felt need for a more balanced development strategy.

The conflicts among the various coastal resources users and people they affect have been discussed by Chia (1985). In the above discussion, the main sources of these conflicts lay in the essentially unisectoral nature of the development agencies involved and their overlapping responsibilities in the management of the resources and space under their jurisdiction. But, there are mechanisms for consultations to take place among these agencies. They have also exhibited greater sensitivity and responsiveness toward the needs and aspirations of other users. For its part, this document will endeavor to discover ways to minimize the conflicts and adverse consequences highlighted in this section through the use of an integrated and multisectoral approach.

The Conflict Matrix

Published examples of conflict matrices for different situations include those put together by Koesobiono et al. (1982), Chia (1985) as well as Healy and Zinn (1985). In the course of reviewing the experience of the United States' CAM efforts on the state level, Healy and Zinn (1985) identified a list of "concerns" under the following three categories:

1. development or use of coastal resources;
2. coastal environment; and
3. environmental development interactions.

A separate list of "concerns" has been drawn for Singapore (Table 5.1). The items show the varied nature and wide range of these concerns which are listed according to the frequency of their citations in reports and documents. Compared to the United States, Singapore's small size, limited coastal resources and great intensity of development would suggest quite a different order of importance as well as a significant number of concerns.

Chapter 5. Coastal Area Management Issues

Table 5.1. Environmental and development concerns in coastal area management in Singapore.

Development concerns	Environmental concerns	Environment/development interactions
Recreation/tourism	Water quality	Erosion/sedimentation
Petroleum industry	Coral reefs	Environmental impact
Energy transportation/ storage	Coastal vegetation	Conflicting use
Energy facility siting	Wildlife	Oil pollution/effects
Facility siting	Public access	Floods/flooding
Ports/waterfronts	Fish/fisheries	Water pollution
Shipping/navigation	Beaches	
Transportation	Marine biology	
Industry	Wildlife	
Commerce	Open spaces	
Population/housing	Cultural/historical resources	
Dredging/filling	Aesthetics	
Marinas/boatels	Air quality	
Seasport		
Agriculture		
Aquaculture		
Water development projects		
Waterfront development		

Source: Healy and Zinn (1985).

The items in Table 5.1 are not in any order of priority, although some would immediately be perceived to be more important and the others, of no great concern now. The perceived priority changes depending on the socio-economic and political situations at different points in time. It is of interest to note that, for Singapore, its perception may have already changed over the last three decades of rapid and sustained development.

Discussion of the Conflicts

The term "conflict" should be interpreted broadly to simply suggest that changes resulting from the activities of one sector trigger the reduction of areal extent, reduction/loss of productivity, curtailment of activity or some other forms of disadvantage for another sector. The conflict may be once and for all, as in the relocation of a shipyard due to the redevelopment of an area in which it had been operating previously for another use. The process leading to the physical removal or change of a particular use may also be gradual and long-lasting as in the case of marine pollution arising from the activities of an industry adversely affecting a recreational amenity. Lee (1991) complained passionately on the loss of the original facilities and sites on the southern coast and the inability of the authorities to provide suitable alternatives for seasport groups and associations. Some uses may be more hostile and inhibiting than others. Some, such as tourist development, may be more

sensitive to the presence of other activities in the vicinity. The resolution of such conflicts may be resolved through a financial arrangement between the parties concerned, a change in the law or administrative ruling, or through a negotiation which may result in some form of cooperation. The last may be conducted between the parties concerned or through the mediation of a third party with or without due process of law.

The Cable Car accident, which occurred in 1984 due to the entanglement of a tall oil rig with the cable cars overhead, presents an interesting case study of conflict resolution. Since the rig was being towed out to the sea from a shipyard in Keppel Harbour during the time of the accident, it involved the shipyard concerned; SDC, which owns the cable car system; the port authority; and the public. STPB became an interested party because of the deaths of several tourists. The trapped passengers in the affected cars were successfully rescued through the assistance of the Singapore Armed Forces (SAF). The government convened a Court of Inquiry to examine the circumstances surrounding the accident and to recommend measures to avoid the recurrence of a similar incident. The same approach has been adopted in other earlier incidents involving the loss of life also to prevent their possible recurrence.

Contingency planning is another approach that has been adopted in the case of combating oil spills. PSA, which has fire-fighting and oil removal capabilities, has developed its Oil Spill Contingency Plan to combat and deal with major oil spills on an emergency basis. In addition, PSA coordinates with a number of parties including all the major oil refining companies which are required to stock suitable dispersants and to contribute vessels and equipment for the cleanup, SAF, organizations such as PA as well as the responsible shipowner(s) of the vessel(s) concerned. In cases where the oil slicks are washed ashore, the public is clearly involved, with voluntary organizations and private individuals taking part in the cleanup. Mock exercises are carried out periodically to focus attention on a problem that will require the continuing alertness of a number of public and private organizations.

COASTAL POLLUTION

Marine pollution and the degradation of the coastal environment lie at the heart of the conflicts among various uses, as suggested by the centrifugal pull between meeting developmental needs and conserving the environment. There are several studies on the water pollution of Singapore, not specifically of its coastal waters, by Chen (1972) and Khoo (1989); oil pollution by Rahman and Chia (1977) and Rahman et al. (1980); and more recently, marine pollution in Singapore by Lim et al. (1990). A detailed study of these subjects will be necessary to determine the management of the different types of pollution which affect the coastal environment to minimize, if not completely prevent them. The report by Chia and Chionh (1987) on the environmental management of Singapore in general also gives details on its

organizational framework, the permissible levels that may be discharged by various toxic substances and the legislation that deals with the control of pollution.

Marine Pollution

A basic conflict underlying the pollution of the coastal environment has been discussed in the earlier sections on port operations, shipping and the petroleum industry. However, equally important is land-based pollution which includes human and agricultural wastes as well as industrial and commercial effluents.

A great deal has been accomplished over the years by MOE, which was established in 1972, in the management of water pollution and solid waste disposal. Perhaps, its outstanding achievement has been the well-publicized waste treatment system which provides most areas of Singapore with a sewerage system (Fig. 5.1) which separates wastewater from cleaner surface

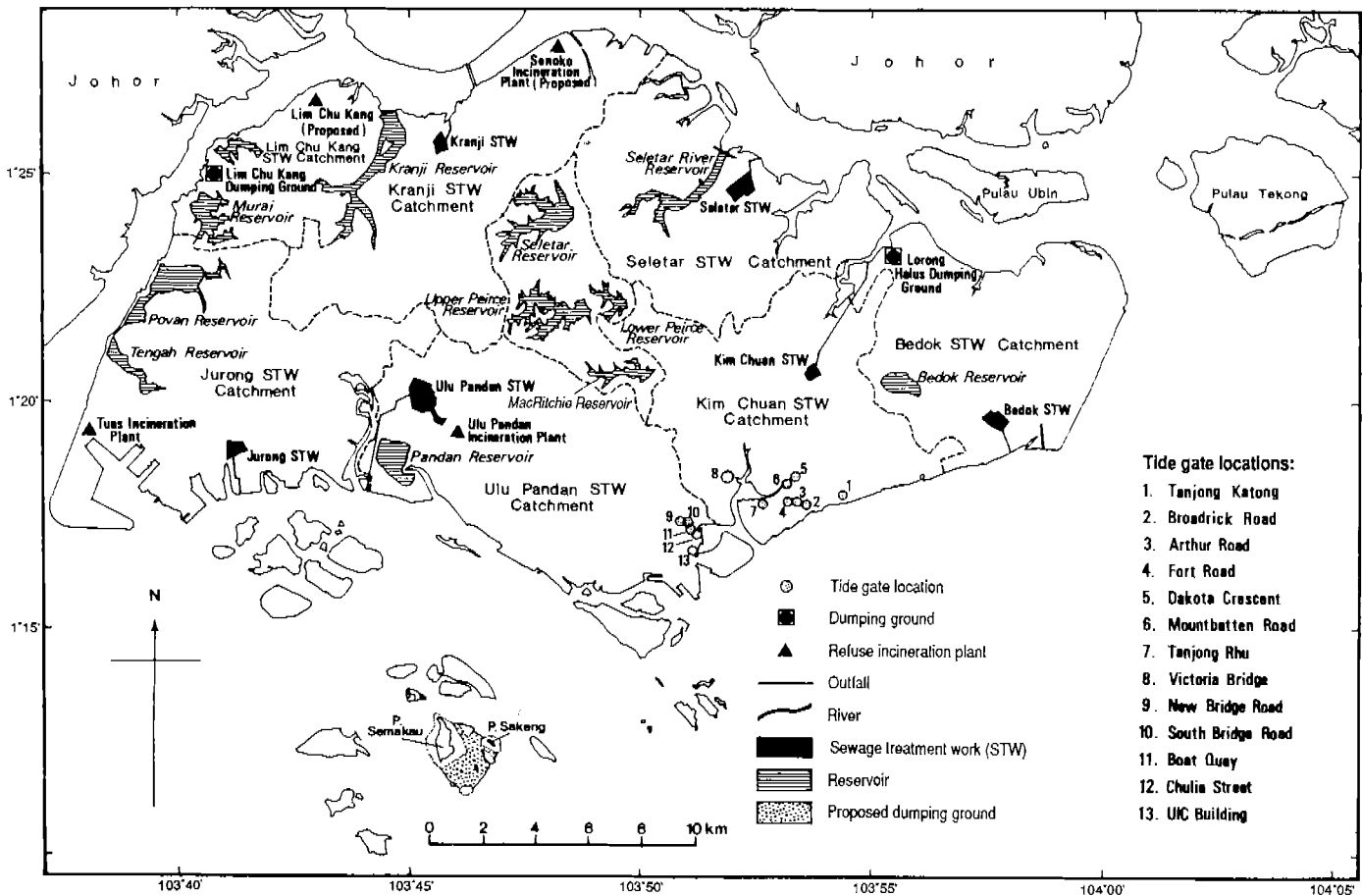


Fig. 5.1. Singapore: catchment areas and environmental aspects.

Chapter 5. Coastal Area Management Issues

water before it is discharged into the open watercourses. Another of its notable achievements centers in the cleaning up of the Singapore and Kallang River basins (Khoo 1989). Envisioned to span ten years, the project recently restricted a large number of pollutive activities, including boat building, food processing and street hawking. It also prohibited the "bucket system" of disposing human wastes from commercial premises and homes within the catchment areas. Moreover, the banks and beds of the two rivers were dredged and, in some places, clean sand was brought in to create beaches. So far, the project has been highly successful in effecting a much cleaner environment which invites fresh opportunities for recreation and commercial developments.

Under a separate component of the ASEAN/US CRMP, MAS of PPD undertook the fish stocking of the Singapore River and also explored the possibilities of planting artificial seagrass in local waters (Lee and Low 1991). The preliminary results have been encouraging, although more work is clearly required to improve on the scheme.

In spite of these achievements, there is the ever present threat of oil spills from ships and land sources finding their way in open drains and eventually ending up in the coastal environment. There has been a suggestion that Marina Bay may be converted into a reservoir, but this will not be possible until the control of all wastewater, solid wastes as well as the disposal of toxic substances is stringently carried out. Also, the possibility of desalinization to extract drinking water in large quantities from seawater remains an option only viable if the oil prices rise considerably higher in the future.

It is common to see oil patches over the sea's surface as well as slicks and tar balls on the shores of both the mainland's coast and offshore islands and on the coral reefs. To develop a world-class resort on the offshore islands, for example, these unsightly and unpleasant evidence of pollution must first be further minimized and removed and the sources from which they are derived, controlled. Although it has been reported that the level of heavy metals in the water and seabed is still low, the impact of these oily and toxic substances can also be severe for aquaculture where fresh clean water is a necessity to maintain high productivity. The recorded occurrence of ships damaged through groundings, collisions or sinkings and, as a result, release large or small amounts of oil into the sea which are washed ashore demonstrates the need for stringent and vigorous surveillance of the ships within port waters. PSA's oil spill contingency plans are only a partial answer to this form of hazard. Moreover, ships carrying toxic chemicals and substances as well as explosive or inflammatory substances, such as liquefied natural gas (LNG) and petroleum gas, are yet other concerns. However, large tankers going through the Main and Phillip Channels are beyond the control of local authorities (see Chia 1981 for a discussion on oil pollution in the Straits of Malacca and Singapore).

In the control of water and marine pollution, more than continued vigilance and monitoring are required. Effective legislation must be introduced and vigorously enforced. Navigational aids must be installed. Tugboat services and treatment facilities for sludge and wastewater for ships coming into port waters must be provided for. As noted by Khoo (1989), it is also necessary to develop control measures to deal with land-based sources of water pollution. Through the Marine Department of the Ministry of Communications, Singapore adopted the *Prevention of Pollution of the Sea Act* in 1991, which laid down the rules and regulations governing vessel and shore installations as well as imposed a hefty S\$500,000 fine for offenders (Alam 1990). The scheme has already produced visible improvements in the port waters, indicating the effectiveness of pollution control through legislation and effective enforcement.

Activities associated with reclamation works along the shores of the mainland and the offshore islands as well as such activities as dredging to deepen the navigational channels for ships calling at the port have produced an enormous amount of silt, causing the poor visibility of the coastal waters. Various measures have been introduced to reduce the outflow of silt-laden water from the reclamation sites (Yong et al. 1991), but the disposal of marine clay excavated from tunnelling works used in the construction of the mass rapid transit system and the underground expressway has posed a major problem. There have been reports of the careless handling of these materials from the time they are put on barges until they are dumped in deep waters, leading to the considerable silting of the coastal waters. To ensure that the pollution of the water is kept at an acceptable level, much more stringent measures will need to be taken to control these activities. Again, it may be necessary to legislate control measures for the strict compliance of the operators involved in the said reclamation projects which produce silt and those handling the disposal of marine clay.

Solid Waste Disposal

The disposal of solid wastes poses another problem for the coastal environment since their quantity has multiplied rapidly over the years as a result of the population's increasing affluence and changing lifestyle. Besides the two incinerator plants, one at Ulu Pandan and a new one in Tuas (Fig. 5.1), there are no more available dumping grounds. MOE has plans to use the area between the islands of Sudong and Semakau as sites for dumping solid wastes and marine clay (Fig. 5.1), but it is feared that the waste materials will release pollutants and even toxic substances which will adversely affect marine life and the environment of the surrounding waters. The presence of the proposed waste disposal site will also be incompatible with the tourist development planned in the nearby islands and the preservation of the unique marine environmental habitats recommended by this document. As there is no better alternative to the creation of this dumping ground which has already affected the coral reefs in the surrounding waters, MOE has

designed retaining walls around the dumping grounds and implemented works to ensure that no seepage of these pollutants occurs in the surrounding environment and what marine life is left is amply protected.

Air Pollution

Air pollution constitutes an important aspect of environmental management especially over areas close to the heavy industries and power generation plants on the offshore islands and the waterfront land. Although these industries' and plants' emissions are tightly controlled by MOE (Chia and Wong 1977; Chia and Chionh 1987), it is a common occurrence to see smoke plumes emitted by the chimneys of factories being kept near the surface under calm conditions especially when there is a temperature inversion. When the smoke settles or is brought down by the rain, oily substances and particles are deposited on the surrounding sea and land surfaces. The adverse visual and olfactory impacts arising from these emissions in the atmosphere constitute problems for the nearby areas used for residential, commercial, recreational and tourism purposes. These impacts can be minimized by controlling the level of emission further by exercising greater vigilance.

Loss of Scenic Quality

The coastal area presents the very best scenic spot in Singapore, especially when viewed from a vantage point. The lively and interesting harbor scene and the picturesque Marina Bay present exciting vistas. In contrast, the waterfront scene in the industrial area is ugly, often bizarre and projects both a sense of revulsion and one of fascination to the viewer, whether from the outside or working there as well. The modern port's very large ships and giant gantry cranes for mechanically handling cargoes are certainly not attractive features. While the industrial islands and the coastal industrial estates have built protective seawalls around themselves, the waterfront is usually kept clear of vegetation to enable the loading and unloading of cargoes and to store materials. The general lack of effort to improve the environment, especially along sections of the seafront not used for cargo handling may be regarded as constituting one form of environmental pollution, except for reasons of safety and effective use of limited space.

The revised Concept Plan recently revealed its intention to build scenic coastal roads with numerous lookout points at selected locations where attractive coastal scenes can be viewed. Legislation requiring the protection of the aesthetic features along the coast and of the coastal ecosystem itself can also be introduced.

NATURAL AND HUMAN-INDUCED HAZARDS

Singapore is fortunate that no natural hazards such as typhoons, tidal waves or earthquakes affect its coastal area for there is currently a growing concern for the long-term possibility of a rising sea level as a result of the warming of the atmosphere due to the greenhouse effect. The evidence

Chapter 5. Coastal Area Management Issues

pointing toward this and its possible impacts on low-lying coastal areas are now being studied by the United Nations Environment Programme (UNEP). Considerable investments have been channelled into the construction of floodgates and the development of flood alleviation schemes to combat the problem of floods during periods of heavy rain.

Far more important than natural hazards are human-induced ones which come from the movement of large objects such as ships and shore vehicles, explosions and fires from industrial plants, and the spills and emissions of hazardous materials by ships and industrial plants or works in the surrounding environment. It is therefore necessary for safety and health reasons to physically separate these structures and to keep them away from the immediate areas around residential grounds, commercial establishments and public places. While the physical planning under the Master Plan has been designed to keep such incompatible land uses away from each other, it is observed that some residential areas are not sufficiently far removed from places where such hazardous activities are being carried out.

In areas where military exercises involve the firing of live ammunition, these places clearly preclude human presence. The southernmost offshore islands of P. Pawai, Senang and a part of Sudong have been reserved for aircraft exercises, although they are made accessible during periods when they are not so employed. Related to this, naval facilities, military camps and installations and their adjacent sea areas as well as vital installations (e.g., telecommunications) are kept off limits to people for security reasons. Thus, in planning coastal area use, the above considerations have to be seriously taken into account.

ISSUES IN COASTAL AREA MANAGEMENT

CAM involves the identification, clarification and, wherever possible, the resolution of issues within the local context. The issues arise from the conflicts among the various users and their activities in limited and restrictive coastal areas. Specifically, the following 12 issues have been modified from the set of recommendations put together at the Second National Workshop on Urban Coastal Area Management in Singapore held 9-10 November 1989 (Chia and Chou 1991). Considering that these issues are to be regarded only as indicative of CAM's condition in Singapore and not as comprehensive as the list is intended to be, each of the items will require further examination with regard to its background, causative factors, interested parties involved, current policies, approaches and management measures, and resolution.

1. Coastal pollution should be minimized or eliminated especially where it diminishes the productive use of coastal resources. While the coastal area is limited, it has so many uses which often give rise to conflicts among two or more of its users. This requires a thorough examination of the level and character of the many forms of pollution that take place from

the area's use, so that appropriate measures and policies can be adopted to prevent, minimize and, if possible, eliminate them.

There are 12 issues indicative of CAM's condition in Singapore. In general, the issues have arisen as a result of the displacement of earlier uses by more recent developments along the coast of the main and offshore islands as well as over the territorial waters.

2. It is important to ascertain the short- and long-term effects of existing and new structures and activities on the coastal environment. The destruction and subsequent alteration of ecological habitats occur when coastal and marine structures are built, when foreshore areas are land-filled, when the seabed is dredged, when marine clays and solid wastes are disposed, when sand and granite are mined, etc. These activities also tend to alter the ecological processes in the surrounding areas which include the hydrological, physical, chemical and biological processes; they also damage the natural ability of living organisms to reestablish or regenerate their community structures, thereby, reducing their ecosystem's natural productivity to varying degrees. This should be restored and wherever possible, augmented.
3. Existing procedures may be inadequate to identify and resolve conflicts among coastal resources users. Conflicts are often generated by activities carried out by users, like dominant agencies, without consultation with others or sufficient consideration given to their impact on other users within the same geographical area. To help forestall possible conflicts and resolve existing ones, joint consultative meetings, informal dialogues and other appropriate channels of communication should be developed. Private organizations and individuals should also be given the opportunity to interact with public agencies. This is particularly necessary since large public agencies are often unisectoral in nature and thus, may be reluctant to open dialogues with the private sector.
4. The need for an umbrella planning body, either consultative or statutory in nature, should be examined. This arises from the third issue that public agencies are unisectoral in nature and as such, do not generally plan the use of these limited sources on a holistic basis which is necessary for maximizing the benefits to be derived from them. Thus, these agencies should be given the responsibility to coordinate with the other large agencies concerned as well as with the interested parties in order to promote the multiple and integrated development of the coastal resources. By doing so, they will be better able to weigh the priorities and options for the use of the available resources and having gained a broader perspective of the needs of all users, be better able to manage them for the maximum benefit of the nation.
5. Environmental conservation of natural and unique habitats to maintain species diversity should be promoted as a desirable national goal. This is now perceived to be increasingly important for a mature and cultured society that seeks to promote a satisfying and conducive environment. There are unique species of coral, fish and other marine organisms,

plants, insects, birds and other animals that are worth preserving even when weighed against pressing developmental needs. There may even be substantially increased material, financial and social benefits to be gained from these species' preservation. Environmental conservation is also closely linked to a clean and healthy environment as well as presents scientific and educational opportunities since a marine reserve is no different from a nature reserve on land.

6. Long-term consideration should be given in utilizing coastal resources to meet recreational and tourism needs. This has already been pursued with regard to the provision of open spaces on coastal land and offshore islands. Portions of seaspace should likewise be provided as recreational outlets for an increasingly leisure-conscious people. These local facilities will reduce the need for Singaporeans to travel to foreign marine tourist destinations, especially if these facilities equal or are even more attractive than those developed elsewhere.
7. Public access to the waterfront, offshore islands and coastal waters should be made easier and more readily available. This is a hotly debated issue in advanced countries. While there are now large coastal parks on reclaimed land which are readily accessible, there are still extensive stretches of the coast completely inaccessible to the public for essential and other reasons. To remedy the situation along scenic coastal roads on the main island, there are plans to build observation points at appropriate sites along the route. Still, serious consideration should be given to opening up access corridors to the waterfront where long stretches of the coast have been blocked completely from public view. Additionally, vantage points on higher ground with a seaward view should be preserved by disallowing buildings or structures that will obstruct a clear line of sight.
8. Multiple and integrated uses of coastal resources should be pursued and promoted. Again, this reflects the unisectoral nature of the public agencies concerned with marine resources use. Efforts should be made to accommodate the compatible uses of the available resources and even to utilize the unused portions of the seaspace more fully. In so doing, the total value of these resources is increased and their full potential maximized.
9. Greater flexibility in the use of coastal resources should be emphasized. Resources under the control of a particular agency may not be required at a particular point in time, such as when they are earmarked for pending development. Also, the use of a particular resource or seaspace may not be continuous, thus, it may be available for other uses during those periods when it is not used. These opportunities for flexible (multiple) use should be explored and taken advantage of.

10. Consideration should be given to prevent activities that may cause irreversible change to the environment and preclude future and new uses of the coastal resources. As a corollary to the last item, special attention should be made to avoid single-purpose uses that once implemented would be irreversible or would incur a very high cost to put to other uses now or in the future. Instead, new and imaginative uses of marine resources which take advantage of technological advances should be promoted. However, if previously existing and traditional uses of the resources are found to still be desirable and beneficial, then these should be revived.
11. There should be less reliance on the efforts of public agencies, and more private community-based participation should be promoted. This is particularly relevant in the area of marine conservation and environmental protection. Properly practiced, it should result in lower maintenance costs and the self-sustained management of marine resources.
12. Both decisionmakers and the public should be made more aware of the value and desirability of environmental conservation. This can be done through the education system and campaigns promoting the proper management of marine reserves and public recreational facilities. Arising from the eleventh item, which is community participation in the management of the resources, this in itself would encourage greater awareness among the public. However, more information regarding the use of marine resources should be made readily available to the public.

It should be mentioned that, for Singapore, there is the will to undertake effective CAM, provided that its objectives are recognized by policymakers at the highest level. This has been demonstrated in other endeavors pursued by the Republic. Considering that the need for improved CAM has already been recognized, it is just a matter of time before improvements are made. Reinforcing this has been the increasing public awareness of coastal environmental conservation, as exemplified in the initiatives taken by the Singapore Nature Society in its proposed Master Plan for the management of the port waters (Lim 1991). URA's Planning Department likewise revised its Long-range Comprehensive Concept Plan, taking into account the need to manage the seaspace, although details have not been released to the public.

CHAPTER 6

COASTAL AREA MANAGEMENT STRATEGIES

In space-short Singapore, where the process of intensive development has been going on for the past three decades, the need to plan and to manage its scarce coastal resources is clearly urgent in view of further developmental pressures. This chapter will then: (1) identify the set of management policies which will deal with the issues raised in the last chapter; (2) design management strategies to help resolve the problems discussed; and (3) focus on selected areas where these strategies can be applied.

As earlier mentioned, there are government agencies concerned with the planning and management of Singapore's coastal resources. PSA has developed a Master Plan for the use of the port waters, while the Planning Department of URA, which has the overall responsibility for the physical planning of the country, has likewise developed a long-range comprehensive land use and transport plan which incorporated in its 1991 revision the use of the waterfront land and all offshore islands. Other marine-related agencies presumably also have development plans for the activities and facilities within the coastal area of Singapore, unlike in other ASEAN member-countries, which have a relatively free hand in planning from scratch their CAM. Thus, in a situation where there already exists a high degree of planning in an intensely developed situation, the present document will be limited to suggesting inputs that may be useful to these agencies in CAM.

MANAGEMENT GOALS AND POLICIES

The basic goal in managing the coastal area of Singapore is to do so in an integrated and multisectoral manner on a sustainable basis.

What are then the achievable goals and policies that may be adopted to guide the developmental strategies to be implemented? The basic goal for the management of the coastal area of Singapore may be stated as follows:

The coastal area of Singapore should be managed in an integrated and multisectoral manner on a sustainable basis in order to maximize the value of the scarce resources available over the long term for the benefit of the nation as a whole.

The above goal may be disaggregated into the following specific strategies:

1. Use of the resources for the entire coastal area should be planned, based on a set of priorities to ensure that the needs of all users are met.

2. Allocation of resources, including seaspace, should take into account existing development plans at the national level and those proposed by relevant agencies.
3. Use of resources, including waterfront land and seaspace, should be integrated with emphasis given to multiple uses rather than single-purpose uses.
4. As in land use planning, a zonation plan should be devised to enable compatible uses to be brought close together while keeping incompatible uses at a distance from each other.
5. The handling and storage of harmful substances and hazardous activities should be kept away from people.
6. In the allocation of resources, flexibility should be maintained, taking into account the different times when the various users are needed.
7. New and imaginative uses of the resources should be given consideration, avoiding irreversible changes and taking into account technological developments.
8. Environmental and resource conservation should be promoted to preserve and rehabilitate the unique character of the local marine ecosystem.
9. The natural scenic beauty and aesthetic quality of the sites found in the coastal area should not be allowed to deteriorate, thus, efforts should be made to conserve, restore and enhance their appeal, wherever possible.
10. Recreation and tourism as well as marine science and education which are compatible with environmental conservation should be encouraged, wherever feasible.
11. The public should be afforded more and easier access to the waterfront, offshore islands and seaspace for their enjoyment.
12. Community-based participation should be encouraged, especially in efforts toward environmental cleanup, natural conservation and recreational uses of marine resources.

**INTEGRATION WITH
NATIONAL AND AGENCY
DEVELOPMENT PLANS**

In existence among a number of national agencies is a high degree of planning for CAM in Singapore. Any other suggested management strategy will, thus, require a careful examination of the existing pattern and character of uses, the current management strategy employed for the resources and the development plans of the agencies.

The national physical planning of Singapore discussed in Chapter 4 involves two plans: the Master Land Use Plan and the Long-range Comprehensive Concept Plan.

The Statutory Master Plan was completed in 1955 and officially adopted in 1958. In 1971, it was realized that it was essentially static in nature and too rigid to cater to the rapidly evolving socioeconomic needs of the country which was subjected from time to time to external unanticipated factors. Thus, the Master Plan is revised every five years in order that it reflects any physical development, known development plans and changes in direction

Chapter 6. Coastal Area Management Strategies

that have taken place during the preceding five-year period. In 1980 and 1985, the revised Master Plan incorporated the detailed plans developed by special agencies, such as HDB and URA, as guidelines for special areas.

On the other hand, the Concept Plan, which was designed to guide development, was completed in 1971. Compared to the Master Plan, it has the advantage of envisaging the overall framework of an integrated physical system which allows development initiated by the agencies concerned to simultaneously take place in stages or phases without undue disruption to the rest of the system. The Concept Plan's short- and long-term goals facilitate the Master Plan's process of planning by giving it direction, thus, one complements the other. The success of this exercise can be demonstrated by the fact that, since the Master Plan adopted the Concept Plan, it underwent just a few modifications (Olszewski and Chia 1991).

However, like the Master Plan, the Concept Plan came up under review in 1988 when it was still under MOND. At that time, each ministry presented its future requirements for space and suggested where the plan could be improved. The planning functions were subsequently transferred to URA in 1989. In 1991, the revised plan embodied such far-reaching changes as a fundamentally different framework, i.e., a decentralized constellation plan (URA 1991) instead of a centralized urban core plan which provided corridors for intensive development. In the constellation urban system, the country is divided into five regions, each with a regional center. Other subplans include those for transportation, industries, recreation's "blue and green" plan and the like, the details of which are still being worked out and awaiting release at some future date.

Physical planning, it should be made clear, has to cover the coastal area and to integrate waterfront land use with marine use in order to maximize the potential of the coastal resources for various purposes. The revised Concept Plan appears to embody this enhanced awareness of the value of coastal areas such as offshore islands and marine space as well as the need to promote marine conservation. Moreover, the planning concept should take a more ecological approach in viewing the interrelationship between the land and the sea across the coastline since land processes and activities have important effects on the surrounding sea areas. Thus, in the utilization of the various offshore islands for industrial, recreational, waste disposal and special uses, consideration should be given to the surrounding seaspace and the resources under its surface. In reclaiming along the waterfront and enlarging or merging islands, consideration should likewise be given to the loss of seaspace and the effects of these activities on the surrounding marine environment. To accommodate these multiple uses of the nation's seaspace, it has been effectively divided into numerous zones, primarily anchorages for ships which come to dock for various reasons (Fig. 4.7), while some areas in Johor Strait have been designated for marine aquaculture. This zoning scheme has, thus, far been applied only to the offshore islands.

In the overall planning of the land and seaspace, another consideration is the balance between both the negative and positive aspects of the seaspace, a peculiar marine character. On the one hand, there is the physical separation which renders movement and access between islands more difficult. On the other, there are the scenic and aesthetic qualities which need to be preserved. Also, the major users of marine resources, such as public agencies like PSA which has overall responsibility in the use of the seaspace, should fully accommodate fishing, marine aquaculture, recreation, tourism and national security in their plans involving shipping and port operations.

**SELECTION OF
APPROPRIATE
MANAGEMENT
STRATEGIES**

Since it is not possible to spell out specific management strategies at this general level of discussion, only broad strategies and needs will be considered here. These management strategies should:

1. identify the management targets;
2. develop appropriate legal provisions and other control mechanisms;
3. develop an appropriate administrative framework; and
4. develop a database system for monitoring and management purposes.

**Identification of
Management Targets**

To improve the management of the coastal resources, it is desirable to focus attention on specific targets of action to be able to prioritize the resources necessary to meet these targets as well as enhance the public's awareness of these needs. In general, attention should be directed at the relatively unused rather than on the more intensively developed parts of the coastal area, such as in the area around the Southern Islands where marine resources have been heavily utilized. Moreover, attention should be directed at the more stringent control of pollution and the interfaces between conflicting uses, and the provision for such needs as marine aquaculture, recreation and tourism. In the case of Johor Strait, the cooperation of the two countries sharing it will be needed to combat the problem of marine pollution from both land and ship sources and to mutually arrive at satisfactory arrangements in the use of the waters for navigation, fishing and marine aquaculture as well as recreation and security. The increased demand for recreational and tourism resources within the coastal area and the greater environmental consciousness among policymakers and the public will also be opportunities to look at areas where the greatest conflicts among various users occur but where their skillful management would help to resolve these conflicts and subsequently enhance nature conservation and prevent marine pollution.

In general, attention should be directed at the relatively unused parts of the coastal area, and at the more stringent control of pollution and the interfaces between conflicting uses, and the provision for such needs as marine aquaculture, recreation and tourism.

There are two areas that would require immediate attention and would benefit from improved management. As mentioned, the first covers the intensively developed Southern Islands and their surrounding waters. The second is the as yet undeveloped 10.2-km² P. Ubin in the eastern portion of Johor Strait where major development plans have been revealed only recently. A preliminary study on the management of the first area has already been done

by Chia (1991), while Pang (1987) undertook a study on the management of the second area. The succeeding discussion of these two areas provides the essential outline of their CAM.

The Southern Islands

As a result of the intensive developments that have taken place on many of these islands for industrial, seaport, recreational/tourist and special purposes over the last three decades, those lying to the southwest of the main island have undergone rapid and drastic physical changes through reclamation and earthworks which in many cases have completely altered their physical landscapes. There are also plans to merge a group of islands consisting of P. Ayer Chawan, P. Seraya and P. Ayer Merbau into a large island (Fig. 4.4) for industrial use. New uses have likewise replaced previous ones, necessitating the movement of human settlements. Needless to say, these changes have severely affected the surrounding waters and seabed.

Fig. 6.1 shows the various uses of the islands as well as some features of the surrounding waters. Developed for various industries, including petroleum refining, petrochemicals and the storage of liquid products, are the islands adjacent the Jurong industrial coast and those as far away as Sebarok. Those used for port operations are P. Brani, P. Sebarok and P. Damar Laut; for special purposes, such as a power generation plant, P. Seraya, and a pigholding station, the reclaimed land on P. Pesek; for military purposes, a group of islands farthest to the south, including P. Sudong, Pawai and Senang; and for recreation/tourist purposes, another group of islands, including the successfully developed Sentosa and those islands to its south. Among this group of islands, St. John's Island is used also as a drug rehabilitation center and a quarantine station. On the 23-ha Lazarus Island, there are plans to develop a beach resort with 100 cottages (*Straits Times*, 31 July 1988 issue). Again, the above activities as well as the busy shipping traffic and port operations that go on in these islands continue to alter and affect the coastal and marine environment of the area.

Besides its use for shipping and port operations, the waters of the Southern Islands are also the home of coral reefs which exhibit a rich species diversity and offer excellent opportunities for developing into a marine conservation area or, as proposed by the author (Chia 1991), a newspaper (*Straits Times*, 14 November 1989 issue) and more recently, by several organizations, a marine reserve or park. In such an intensively developed coastal area where conflicts presently exist among various uses, but where opportunities for further resource use include the multiple enhancement of existing as well as new uses, there is clearly a need for comprehensive management planning. The process of planning would also identify interfaces where conflicts need to be minimized or removed and areas in the coastal environment which should be rehabilitated or enhanced. Moreover, a multisectoral integrated plan would maximize the islands' and the surrounding waters' resources use.

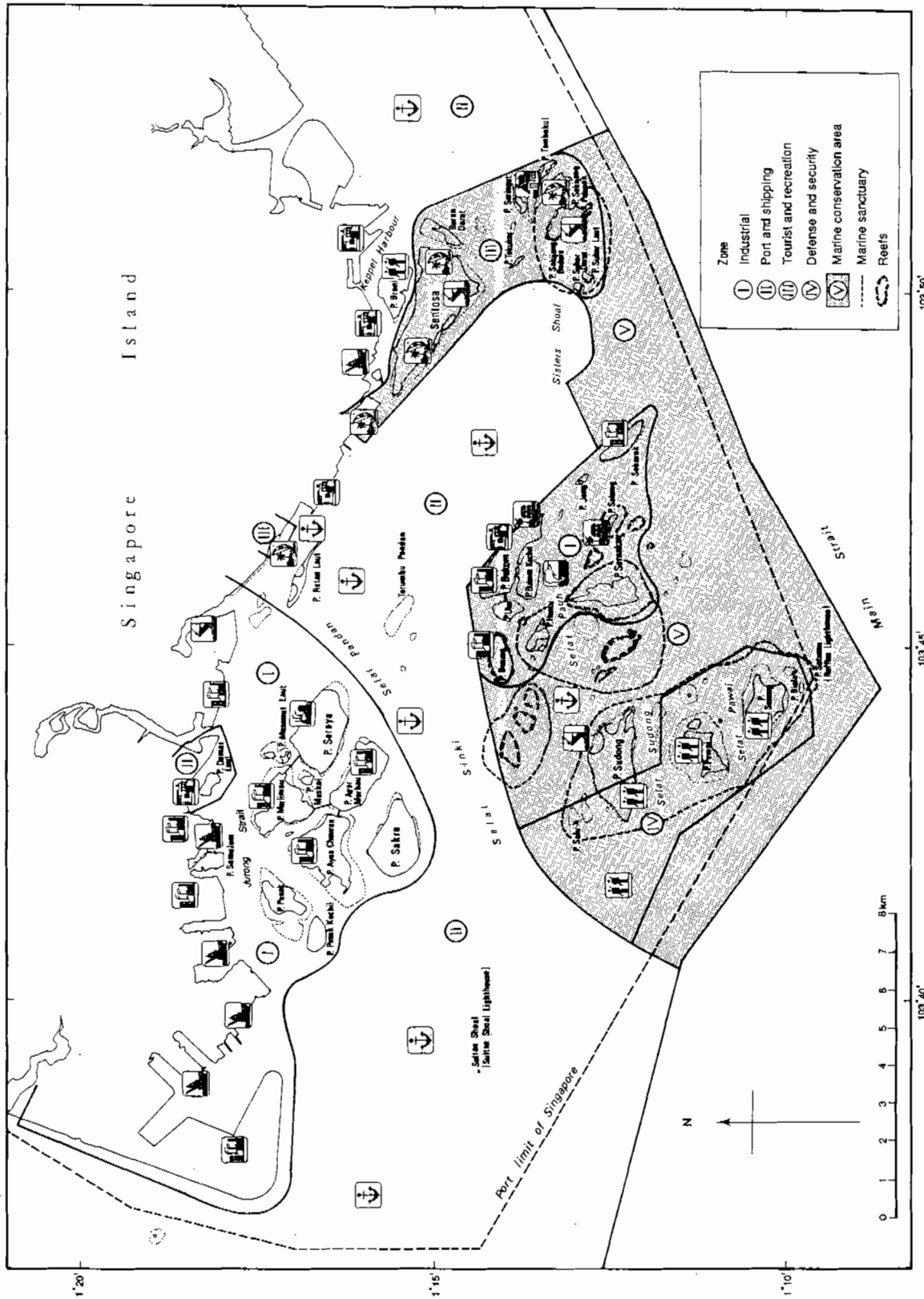


Fig. 6.1. Singapore: zonation scheme for the Southern Islands.

Specific plans, such as that proposed by Chia (1991), indicate the development of a marine conservation area covering all the islands and surrounding waters for military use as well as the development of recreational/tourist/industrial islands. Another scheme which proposes the conservation of coral reefs in the same area has been put forward more recently by three organizations—RSYC, SIB and SUF (hereinafter referred to as the Group). The scheme has been supported by SSLC and the National Council of the Environment (1991).

In the course of undertaking extensive surveys, the Group identified reefs with various proportions of live coral cover in the waters of the Southern Islands. Its recommendation calls for some form of conservation and management of the reefs around four groups of islands (Fig. 6.1), namely:

1. P. Hantu and the patch reefs to the west of it, including those in T.P. Laut, T.P. Tengah and T.P. Darat;
2. the islands of Lazarus, St. John's and the Sisters;
3. the northern and western coasts of P. Semakau and the patch reefs on the eastern border of the Live-Firing Restricted Zone, including Terumbu Raya, Terumbu Bemban, Beting Bemban Besar, Terumbu Palat and Terumbu Menalung; and
4. P. Salu to the northwest, P. Sudong, P. Pawai, P. Senang, P. Biola and Raffles Lighthouse to the south, including the patch reefs between these islands.

The third plan (shown in Fig. 6.1), which incorporates the features of both the first and second proposals, suggests the following scheme:

1. Marine sanctuary: It includes all four areas earlier identified by the Group. However, its proposal differentiates the easternmost area for marine recreation, while the other three are for scientific research. Where the corals, seagrasses and algae can be best developed, fishing will not be allowed; so will boats be restricted, so that marine life will be able to grow completely undisturbed, thereby, allowing it to reestablish its original condition. The damage sustained from live-firing exercises within the Live-Firing Zone does not appear to be serious since the area is off limits to the public, hence, the corals therein are adequately protected. Nevertheless, army personnel undertaking exercises within the area should be instructed on the conservation rules and guidelines to be adopted.
2. Conservation zone: This is the larger area surrounding the sanctuary area not used as navigation channels or anchorages for merchant ships. Since it is intended to act as a buffer to the sanctuary, thus, it should be protected from further damage. Boats should be provided with anchors or buoys to enable them to secure themselves without dropping anchor. Spearfishing and collecting of corals, fish and seagrasses will not be permitted. Sportfishing will be allowed but subjected to controls.

Chapter 6. Coastal Area Management Strategies

It should be noted here that appropriate legislation will have to be passed to establish the conservation scheme since the "undeveloped" islands of Sudong, Semakau, Sakeng and other small islets have already been earmarked for industrial development. However, the urgency for acquiring more land for industrial uses is at present no longer as acute as there is a substantial portion of reclaimed land in Tuas, although the "development" of the islands in the future when the demand for land again peaks will test the resolve of the nation in conserving its valuable natural resources as represented by the coral reefs.

In the light of the foregoing, the Conservation Plan presents such considerations as:

1. raising the standard of the water quality of the effluents from the industrial plants on the nearby islands;
2. using all means to remove shipboard wastes and effluents and to minimize ship-source pollution;
3. identifying and conserving the linked habitats on the offshore islands within the sanctuary and, wherever possible, within the conservation zone;
4. rehabilitating the soil and vegetation on the offshore islands within the sanctuary and conservation zone and improving the environmental condition of the islands used for industrial and other purposes;
5. identifying potential sites for nature conservation and establishing bird sanctuaries on the islands;
6. setting guidelines for setbacks from the shore zone and the conservation and rehabilitation of natural habitats;
7. exploring the possibility of maintaining a limited population on P. Sakeng and other islands within the conservation zone and assessing the adequacy of employment, social and educational opportunities for these island-communities;
8. exploring ways to reroute large ships away from the conservation zone and restricting the zone for anchorages as much as is feasible;
9. developing facilities, such as marine trails, signs, marker buoys and anchor points for small boats, to conserve fish, corals and other marine life;
10. implementing measures to prevent littering, destruction, damage and removal of marine life and seabed materials;
11. ensuring minimum leakage from the solid waste disposal site located between P. Semakau and P. Sakeng;
12. undertaking a feasibility study for establishing an undersea observation facility;
13. undertaking further research on the marine life and environment which could form the basis for any modification on the proposed conservation and sanctuary areas; and
14. developing educational materials and undertaking an awareness program for the public.

To successfully implement the above Conservation Plan, it will be imperative to establish a management organization to enforce the rules; undertake the necessary improvements on the environment and physical facilities to better cater to the needs of visitors; and monitor the resources and level use. To make the scheme viable, an appropriate authority will have to either publicly or privately operate the said management entity from solicited funds substantial enough to establish and operate it. In addition, it may be unavoidable to charge visitors a fee to cover operating expenses. Community participation should, thus, be encouraged as it may perhaps be essential for the scheme's successful operation.

Pulau Ubin in the East Johor Strait

Lying northeast of the main island is this fairly large island which is hilly and rugged in places, relatively undeveloped and still used in a traditional manner (Fig. 6.2). A large part of the island is vegetated mostly by old, abandoned rubber plantations where there may be fruit trees planted and grown by the local inhabitants. There are two patches of scrub/secondary vegetation on two ends of the island. In the center of the island are quite extensive mangrove areas and the estuaries of small streams, some of which have been converted into shrimp ponds. This includes the small adjacent island of P. Ketam. P. Ubin still has a rich flora, bird and animal life, attracting many hikers, campers and nature lovers from the main island. The island has been identified by MNS' Master Plan for the Conservation of Nature (1990) as worthy of conservation and has recommended it as a wildlife sanctuary and public park with suggested facilities to be erected for recreational and educational uses.

The granite found on the island continues to be extracted, resulting in deep large holes in the ground. There are a number of *kampong* along the coast, and a fairly good system of paved roads serve the islanders who have inhabited the island probably before this century. The International OBS is situated on the western end of the island. To cater to the increasing number of visitors from the main island, a number of small rest houses have been built on the island. There are regular ferry services and bumboats operating out of Changi Point and Punggol on the main island, bringing groups of school children and hikers to the island.

To the south of the island are a good number of netcage farms, traditional *kelong* in the waters around it as well as a modern shrimp farm. The main employment is derived from granite quarries and shrimp ponds. But many of the Malay *kampong* folk have migrated to the main island for better employment opportunities. Judging from the absence of working fishing boats in the villages, there are no longer any fishermen on the island. Only the old people and some children remain there.

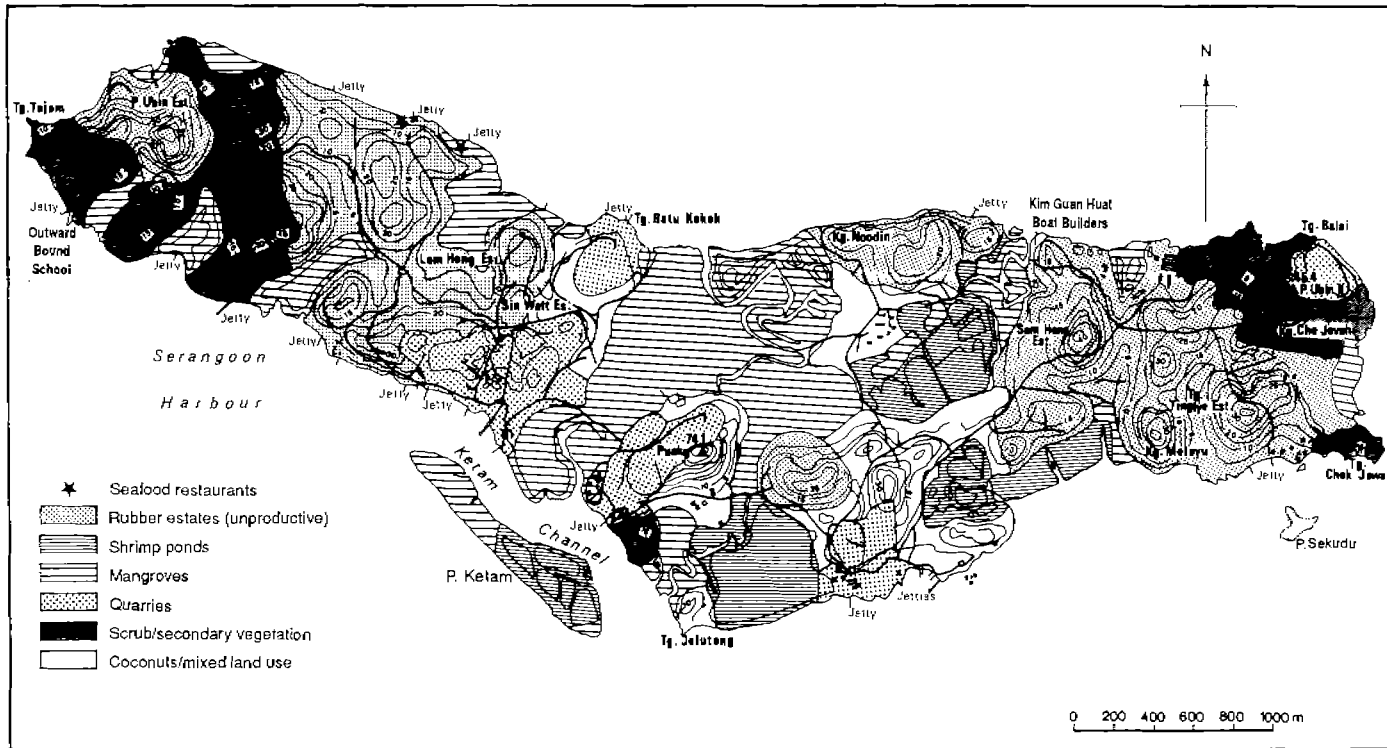


Fig. 6.2. Singapore: Pulau Ubin.

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The island is one of the few still as yet unallocated for development purposes. Earlier proposals are designed to develop the island into one for recreation-cum-primary production. For example, the revised Concept Plan envisages the eventual extension of the mass rapid transit line across P. Ubin and P. Tekong to link them to the main island. It is also envisaged that both these islands will be developed to accommodate some industries. In the case of P. Ubin, about a third of the island will be devoted to industrial uses. High-density housing and commercial developments are likewise planned on these islands. However, for the immediate future, P. Ubin will be developed to provide open spaces and recreational facilities (URA 1991).

At present, P. Ubin is underutilized for a whole range of uses that its large space demands. Instead, the increasing number of campers, trekkers and seekers of nature from the main island has already caused considerable damage to its natural vegetation. Clearly, there is a need for a management plan to enhance the environment by finding better use of the land and other resources on the island. However, the Minister of National Development announced the ministry's plan to further develop OBS on the western end of the island. Also important is the protection of what is left of the stands of forests and patches of mangroves. Appropriate measures will then have to be taken to provide guidelines for their use and facilities to accommodate the growing number of visitors to the island. Such a management/development plan will need to account for the following:

1. better management of the relatively natural condition and endowment of the island, i.e., rich flora and fauna, rugged terrain and physical separation from the main island in order to increase the benefits from its recreational, educational and scientific uses;
2. institution of better control to prevent the further scarring of the landscape and to preserve the aesthetic beauty of the island;
3. further augmentation of the island's recreational potential, some of which have already been developed, by providing more and better facilities for more but not an unlimited number of visitors on the island which could later lead to its development as a holiday resort and playground for the main islanders;
4. adequate control of the handling of the granite chips and fragments to be transported to makeshift jetties, an activity which introduces considerable silting and environmental damage to the surrounding waters;
5. introduction of more modern intensive shrimp farms (there is one such farm) into the island to prevent the further uncontrolled destruction of the mangroves which is done to give way to the traditional type of shrimp farming which is based on the impoundment of a cleared area of mangroves;
6. reserved use of a good part of the sea surrounding the island for netcage fishfarms which have already been proven to be profitable;
7. further improvement of the quality of the seawater, which has been found to have a high coliform count due to the farming activities on the

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- main island, although efforts have been made to purify the water to levels good for mariculture and safe for recreational use;
8. provision for properly designed and constructed *kelong* with facilities which can readily render food and recreational services to cater to holiday makers and tourists;
 9. development of employment opportunities associated with farming as well as recreational and tourist facilities and services to attract more inhabitants back to the island where the traditional villages (*kampong*) are themselves tourist attractions since the people's way of life on the island has been preserved; and
 10. institution of legal measures to prevent further damage to the island's valuable vegetation and wildlife and, through the participation of private bodies and individuals, conserve these resources.

To summarize, the island of P. Ubin has considerable potential to be more intensively used, provided that its natural endowments and resources are properly managed and the island is developed with a wide range of public facilities in order that it can operate as a recreational and tourist resort and, at a later date, possibly include some high-density residential and even industrial areas. More frequent and fast ferry services, improved jetties and a system of roads with direct links via a bridge or undersea tunnel by rail would help its development immensely. Beyond that, eventual links with the Malaysian territory should be considered because of its proximity to the Malaysian coast. It will then be necessary to cooperate with the Johor State authorities in matters of pollution control, illegal movement of people and goods, and security.

Development of Appropriate Legislation

The relevant legal provisions for CAM are scattered among numerous laws, including the Environmental Act, the Port of Singapore Act, Pollution of the Sea Act, the Foreshore Act, the Building Control Act and others. To ascertain whether they are in combination adequate to deal with all the needs of the comprehensive CAM planning that may arise, it will be necessary to systematically examine these provisions.

If, for example, the proposal for a marine conservation scheme is to be accepted, new legislation will be required. For the industrial plant located within the coastal area, there may be a need to raise the permissible levels of toxic materials in the wastewater that they discharge into the sea and air emissions that come from their chimneys, if these are found unacceptable by other major users in the coastal area. There may also be a need to assign additional responsibilities to existing agencies, if their jurisdiction requires that they cover other aspects of CAM. This would certainly be necessary if an umbrella body is to be created to take charge of CAM as a whole. Apart from controlling the movement of vessels, marine pollution, the use of seaspace for recreation, fishing, and aquaculture, erecting marine structures currently comes under the supervision of PSA.

FURTHER RESEARCH

Further research in a number of aspects relating to CAM will be necessary. Three such studies might include a detailed analysis of coastal recreation and marine tourism, marine aquaculture and coastal pollution.

Further research on a number of aspects relating to CAM will be necessary in addition to the study of the legal provisions embodied in the laws of the sea and the management of the Southern Islands and P. Ubin. Three such studies might include a detailed analysis of coastal recreation and marine tourism, marine aquaculture and coastal pollution.

Coastal recreation and marine tourism have become increasingly important, as indicated by the development of large coastal parks and a number of off-shore islands, including Sentosa, for these purposes. The impacts of these activities on the marine environment should be examined, keeping the adjacent uses of the coastal area compatible and the hard uses at a distance. The proposal to develop parts of the Southern Islands into a marine conservation area should also be examined, if it caters to these needs. Other relevant aspects concern the problems of marine and, more broadly, environmental pollution as these relate to the protection of the people's health, safety and security.

Marine aquaculture, it has been found, both on land and in the sea, the latter in the form of the traditional *kelong* and netcage culture, is compatible with the intensive use of space for the production of food. As earlier suggested, *kelong* can be combined with leisure and tourist uses. However, it is important to bear in mind that the quality of the seawater is vital to aquaculture and relates to coastal pollution. Apart from the agrotech farming areas already designated (Fig. 4.15), suitable sea areas with favorable conditions for intensive netcage culture should be identified and reserved. For this form of activity, calm, clean, shallow waters are preferred. Thus, siting should be far away from where large vessels usually pass.

On coastal pollution, a detailed study should be carried out, dealing with the various forms of pollution, their sources and treatment facilities. While the maps provided sectional designs where these can be found and the earlier section on the "Integration with national and agency development plans" discussed the problems encountered in this study area and other pertinent information, a more thorough investigation of the causes, extent and level of pollution will greatly assist the management of the coastal area.

Moreover, in the course of this research, such important information gaps as the lack of knowledge of the physical/chemical properties of the sea and seabed conditions became apparent. Also lacking is information on the current use level of various resources by recreational fishermen, seaports enthusiasts and collectors of marine fish, corals and other organisms. To fill this deficiency to help properly manage the coastal area, a database should thus be developed.

**INSTITUTIONAL
ARRANGEMENTS**

The public agencies concerned with Singapore's CAM and their functions have been identified in Chia et al. (1988). Foremost among these agencies is PSA, which is responsible primarily for most parts of the local seaspace as well as land. The PSA is supported by other agencies, including the Ministry of Communications; MOE; HDB for housing; JTC for the manufacturing industries; the Public Utilities Board for coastal reservoirs, waterways as well as power generation plants; the Ministry of Defense; PPD in MOND for fisheries, aquaculture and agriculture; the Public Works Department also under MOND for road construction and other public works projects; the Marine Police and the Customs Department in the Ministry of Home Affairs; and others.

Whether or not there should be a separate umbrella agency to coordinate and manage the coastal area as a whole is a matter for discussion. It is possible to subsume the task under the Planning Department of URA which is already charged with the overall physical planning of the nation. An alternative would be to assign this added responsibility to PSA, although its primary concern is the management of the seaspace rather than all of the coastal areas. The diverse and varied uses of the coastal area would suggest that the formation of a separate coastal area authority would be more appropriate.

CONCLUSION

In a severely land-short and heavily populated small nation like Singapore, the demand for land and other resources to meet the needs of a rapidly expanding economy and society requires that every effort must be made to identify and take up opportunities to maximize its coastal resources. To achieve this, an integrated multisectoral approach must be adopted in order to meet the country's environmental imperatives as well.

Much has already been achieved in the management of Singapore's coastal areas through careful planning and the effective implementation of developmental projects. As shown by the nation's achievements as the world's busiest shipping port and premier container port, the sustained high growth of the manufacturing sector which accounted for nearly a third of the nation's GDP, with many of the industries presently located within the coastal zone, including the offshore islands, the results have been truly spectacular. The success of Sentosa as a resort island is also symbolic of the development of waterfront land and offshore islands where recreational facilities have become attractions to both the local residents and tourists alike. Moreover, the coastal zone accommodates numerous other essential uses and activities and together contribute toward the overall economic and social growth of the nation.

However, these developments wrought dramatic changes on the country's coastal area through the powerful process of land reclamation and the equally high-impact construction of shore and marine structures. As a result, little of the coastal zone has been left untouched with plans being drawn up

Generally, the imperatives of economic development have necessarily taken precedence over environmental concerns, although there is a new tide of environmental consciousness.

for the eventual intensive development of the two largest offshore islands, P. Ubin and P. Tekong. These physical changes and the activities associated with industrial and other developments have had far-reaching effects on the surrounding coastal waters, seabed and marine life. Generally, the imperatives of economic development have necessarily taken precedence over environmental concerns. This is likely to continue as shown by both ongoing and planned projects, although the 1980s ushered in the expressed and real concern for environmental conservation and enhancement in the Republic. Among other reasons for this new tide of environmental consciousness has been the need to strive for a better quality of life for the population as befitting the status of an advanced maturing society.

While there has been a great deal of planning for the use of the coastal resources and space in Singapore, it has been undertaken primarily by specialized agencies. The plans are basically unisectoral in nature with the exception of those affecting offshore islands under the Long-range Comprehensive Concept Plan by URA. A good deal of consultations with PSA, the main agency concerned with the use of the coastal resources, and other agencies involved with recreation and other uses was likewise noted. Instead, this document suggested that an umbrella planning authority to oversee the entire coastal area of Singapore would be much more effective in undertaking comprehensive planning for the long-term sustainable development of the resources.

All in all, this document put together a fairly comprehensive set of information to assist those responsible for coastal area planning. Maps have been designed for visual reference. It also discussed the conflicts among the various users; the details of these uses were documented in Chia et al. (1988). Also, attention was drawn to two examples—the cases of the Southern Islands and P. Ubin and the surrounding waters in Johor Strait—to illustrate the need for comprehensive coastal area planning. Both the government's and the public's growing concerns and expectations relating to an enhanced environment and the need for action to encourage nature conservation were reflected in this chapter's call for the establishment of a marine conservation scheme as part of the comprehensive plan which will protect and beautify the coastal area within the Southern Islands. Indeed, if this document succeeds in generating a sustained enthusiastic response to meet the challenges that lie ahead, then it would have served its purpose.

REFERENCES

- Alam, Z. 1990. The Prevention of Pollution of the Sea bill. Paper presented at the Singapore Naval Architects and Marine Engineers Society, 24 August 1990. World Trade Centre, Singapore (Unpublished).
- Amarasinghe, S.R., H.J.M. Wickremeratne and G.K. Lowry, Jr. 1987. Coastal zone management in Sri Lanka, 1978-1986, p. 1995-2006. *In* O.T. Magoon, H. Converse, D. Miner, L.T. Tobin, D. Clark and G. Domurat (eds.) Coastal Zone '87. American Society of Civil Engineers, New York.
- AMSA (Australian Marine Sciences Association). 1977. Guidelines for the protection and management of estuaries and estuarine wetlands. Australian Marine Sciences Association, Sydney.
- Chao, H.T. 1989. Paper on Singapore: Law of the Sea, p. 1-12. *In* The United Nations Convention on the Law of the Sea in Southeast Asia: problems of implementation. Southeast Asian Programme on Ocean Law, Policy and Management, Institute of Southeast Asian Studies, Singapore.
- Chen, H. 1972. Water pollution and its control in Singapore, p. 29-32. *In* Anon. Towards a clean and healthy environment. Ministry of the Environment, Singapore.
- Cheong, L.J. 1988. Review of the status of aquaculture in Singapore, p. 1-9. *In* Anon. Seventh Session of the IPFC Working Party of Experts on Aquaculture, 1-6 August 1988. Bangkok, Thailand. IPFC WPA/WP9. Food and Agriculture Organization, Rome.
- Chia, L.S. 1981. The Straits of Malacca and Singapore: navigational, resource, and environmental considerations, p. 239-263. *In* L.S. Chia and C. MacAndrews (eds.) Southeast Asian Seas: frontiers for development. McGraw-Hill, Singapore.
- Chia, L.S. 1982. Singapore: coastal zone resource use and management, p. 241-252. *In* C.H. Soysa, L.S. Chia and W.L. Collier (eds.) Man, land and sea: coastal resource use and management in Asia and the Pacific. Agricultural Development Council, Bangkok, Thailand.
- Chia, L.S. 1985. Utilization and management of Singapore's coastal zone, p. 51-54. Proceedings of the MAB/COMAR Regional Seminar on Man's Impact on Coastal and Estuarine Ecosystems, 13-16 November 1984. Tokyo, Japan. Man and Biosphere Programme, Paris.
- Chia, L.S. 1989. The port of Singapore, p. 314-336. *In* K.S. Sandhu and P. Wheatley (eds.) Singapore: the management of success. Institute of Southeast Asian Studies, Singapore.
- Chia, L.S. 1991. A proposed management plan for the coastal area surrounding the Southern Islands of Singapore, p. 444. *In* L.M. Chou, T.-E. Chua, H.W. Khoo, P.E. Lim, J.N. Paw, G.T. Silvestre, M.J. Valencia, A.T. White and P.K. Wong (eds.) Towards an integrated management of tropical coastal resources. ICLARM Conference Proceedings 22, 455 p. National University of Singapore, Singapore; National Science and Technology Board, Singapore; and International Center for Living Aquatic Resources Management, Manila, Philippines.
- Chia, L.S. and Y.H. Chionh. 1987. Singapore, p. 109-168. *In* L.S. Chia (ed.) Environmental management in Southeast Asia: directions and current status. Faculty of Science, National University of Singapore, Singapore.
- Chia, L.S. and L.M. Chou, editors. 1991. Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines.
- Chia, L.S. and S.F. Foong. 1991. Weather and climate, p. 13-49. *In* L.S. Chia, A. Rahman and D.B.H. Tay (eds.) The biophysical environment of Singapore. Singapore University Press, Singapore.
- Chia, L.S. and H. Khan. 1987. Utilization of offshore islands off an urban waterfront: the case of Singapore, p. 4624-4638. *In* O.T. Magoon, H. Converse, D. Miner, L.T. Tobin, D. Clark and G. Domurat (eds.) Coastal Zone '87. American Society of Civil Engineers, New York.
- Chia, L.S. and J.M.L. Wong. 1977. Atmospheric pollution and its control in Singapore, p. 100-123. *In* C.S. Hew and L.L. Koh (eds.) Proceedings of the Symposium on Our Environment. Institute of Natural Sciences, Nanyang University, Singapore.
- Chia, L.S., H. Khan and L.M. Chou. 1988. The coastal environmental profile of Singapore. ICLARM Technical Reports 21, 92 p. International Center for Living Aquatic Resources Management, Manila, Philippines.
- Chia, L.S., H.C. Lee, A. Rahman, P.L. Tong and W.K. Woo, editors. 1986. Proceedings of the Conference on the Biophysical Environment of Singapore and its Neighbouring Countries, 3-5 May 1985. Singapore University Press, Singapore.

References

- Chia, L.S., G.S.Y. Lim and L.M. Chou. 1990. Reef resources of Singapore: utilization pattern and management, p. 761-764. *In* R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.
- Chong, P.F. 1985. Ecology of the coral community of Pulau Hantu. Department of Zoology, National University of Singapore. B.Sc. honors thesis.
- Chou, L.M. 1986. The coral reef environment in Singapore, p. 93-102. *In* L.S. Chia, H.C. Lee, A. Rahman, P.L. Tong and W.K. Woo (eds.) Proceedings of the Conference on the Biophysical Environment of Singapore and its Neighbouring Countries, 3-5 May 1985. Singapore. Singapore University Press, Singapore.
- Chou, L.M. 1988. Long-term effects of sedimentation on the reefs of Singapore. *In* Proceedings of the Annual Seminar of the Environmental Management and Research Association of Malaysia, 31 March-4 April 1988. Malaysia.
- Chou, L.M. and L.S. Chia. 1991. The marine environment, p. 155-184. *In* L.S. Chia, A. Rahman and B.H.D. Tay (eds.) The biophysical environment of Singapore. Singapore University Press, Singapore.
- Chou, L.M. and Y.H. Teo. 1985. An ecological study on the scleractinian corals of Pulau Salu reef, Singapore. *Asian Mar. Biol.* 2: 11-20.
- Chou, L.M. and F.J. Wong. 1984. A note on the distribution of marine macroalgae at Pulau Salu J. Singapore Natl. Acad. Sci. 13: 23-24.
- Chou, L.M. and F.J. Wong. 1985. Reef community structure of Pulau Salu (Singapore), p. 285-289. *In* Proceedings of the Fifth International Coral Reef Congress, June 1985. Tahiti.
- Chua, T.-E. and A.A. Agulto. 1987. ASEAN/US Cooperative Program on Marine Sciences: Coastal Resources Management Project research, training and information programs and activities 1986-1989. ASEAN/US CRMP Work. Pap. 87/13. International Center for Living Aquatic Resources Management, Manila, Philippines.
- Chua, T.-E. and D. Pauly, editors. 1989. Coastal area management in Southeast Asia: policies, management strategies and case studies. ICLARM Conference Proceedings 19, 254 p. Ministry of Science, Technology and the Environment, Kuala Lumpur; Johor State Economic Planning Unit, Johore Bahru, Malaysia; and International Center for Living Aquatic Resources Management, Manila, Philippines.
- Clark, J.R. 1977. Coastal ecosystem management: a technical manual for the conservation of coastal zone resources. John Wiley and Sons, New York.
- Clark, J.R. 1985. Coastal resources management: development case studies. Research Planning Institute Inc./National Park Service, USDI/United States Agency for International Development, Washington, D.C.
- Corlett, R. 1991. Vegetation, p. 134-154. *In* L.S. Chia, A. Rahman and D.B.H. Tay (eds.) The biophysical environment of Singapore. Singapore University Press, Singapore.
- DOS (Department of Statistics) 1983. Yearbook of statistics. Department of Statistics, Singapore.
- DOS (Department of Statistics) 1988. Yearbook of statistics. Department of Statistics, Singapore.
- DOS (Department of Statistics) 1989. Yearbook of statistics. Department of Statistics, Singapore.
- DOS (Department of Statistics) 1990. Yearbook of statistics. Department of Statistics, Singapore.
- Fung, O. 1991. Development of coastal parks in Singapore, p. 105-108. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines.
- Gilbert, J.T.E., editor. 1982. Environmental planning guidelines for offshore oil and gas development. Environment and Policy Institute, East-West Center, Hawaii.
- Goh, C.W. 1991. Opening address-Singapore's coastal area development: promises for the 1990s. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines.
- Gomez, E.D. 1980. The present state of mangrove ecosystems in Southeast Asia and the impact of pollution. 80/WP/947. South China Sea Fisheries Development and Coordinating Programme, Manila.

References

- Gomez, E.D. 1989. Coral reef resources and the ASEAN/US Coastal Resources Management Project, p. 17-26. *In* T.-E. Chua and D. Pauly (eds.) Coastal area management in Southeast Asia: policies, management strategies and case studies. ICLARM Conference Proceedings 19, 254 p. Ministry of Science, Technology and the Environment, Kuala Lumpur; Johor State Economic Planning Unit, Johore Bahru, Malaysia; and International Center for Living Aquatic Resources Management, Manila, Philippines.
- Hamilton, L.S. and S.C. Snedaker, editors. 1984. Handbook for mangrove area management. Environment and Policy Institute, East-West Center, Honolulu, and United Nations Environment Programme, Paris.
- Healy, R.G. and J.A. Zinn. 1985. Environment and development conflicts in coastal zone management. *J. Am. Plann. Assoc.* 51(3): 299-311.
- Hsu, L.H.L. and L.M. Chou. 1989. Seagrass communities in Singapore. Paper presented at First Southeast Asian Seagrass Resources Research and Management Workshop, 17-22 January 1989. Manila.
- Khan, H. 1991. Economic valuation of Singapore's coastal resources. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines. p. 81-94
- Khoo, C.H. 1989. Cleaning up the Singapore River, 97-101. *In* T.-E. Chua and D. Pauly (eds.) Coastal area management in Southeast Asia: policies, management strategies and case studies. ICLARM Conference Proceedings 19, 254 p. Ministry of Science, Technology and the Environment, Kuala Lumpur; Johor State Economic Planning Unit, Johore Bahru, Malaysia; and International Center for Living Aquatic Resources Management, Manila, Philippines.
- Khoo, C.H. 1991. Land-based sources of pollution of the coastal waters of Singapore. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines. p. 77-80
- Kiravanich, P. and S. Bunpapong. 1989. Coastal area management planning: Thailand's experience, p. 215-229. *In* T.-E. Chua and D. Pauly (eds.) Coastal area management in Southeast Asia: policies, management strategies and case studies. ICLARM Conference Proceedings 19, 254 p. Ministry of Science, Technology and the Environment, Kuala Lumpur; Johor State Economic Planning Unit, Johore Bahru, Malaysia; and International Center for Living Aquatic Resources Management, Manila, Philippines.
- Koesobiono, W.L. Collier and P.R. Burbridge. 1982. Indonesia: resources use and management in the coastal zone, p. 115-133. *In* C. Soysa, L.S. Chia and W.L. Collier (eds.) Man, land and sea: coastal resource use and management in Asia and the Pacific. Agricultural Development Council, Bangkok, Thailand.
- Lee, F.C.H. 1991. Cinderella-in-waiting: the problems and prospects of seaports development in Singapore. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines. p. 99-104
- Lee, F.C.H., S.H. Loo, S.S. Khoo and L.M. Chou. 1991. A proposal for the conservation of coral reefs in Singapore. Singapore Reef Survey and Conservation Project, Republic of Singapore Yacht Club, Singapore Institute of Biology and Singapore Underwater Federation, Singapore.
- Lee, H.B. and J. Low. 1991. The enhancement of fish community in the Singapore River, p. 21-29. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines. p. 21-30
- Lim, G.S.Y. and L.M. Chou. 1989. Studies of reef fish communities in Singapore. ASEAN-Australia Coastal Living Resources Project First Regional Symposium, 8-12 August 1988. Manila.
- Lim, G.S.Y., L.M. Chou and L.S. Chia. 1989. The biological communities of the coral reefs of Singapore with emphasis on reef fishes and hard corals, p. 381-384. *In* R. Hirano and I. Hanyu (eds.) The Second Asian Fisheries Forum. Asian Fisheries Society, Manila.

References

- Lim, G.S.Y., L.M. Chou and H.W. Khoo. 1990. Marine pollution research in Singapore. *In* H.T. Yap, M. Bohle-Carbonell and E. Gomez (eds.) *Oceanography and marine pollution: an ASEAN-EC perspective*. Marine Science Institute, Quezon City, Philippines.
- Lim, K.W. 1991. Management and utilization of Singapore's port waters: new directions, p. 11-20. *In* L.S. Chia and L.M. Chou (eds.) *Urban coastal area management: the experience of Singapore*. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines. p. 11-21
- Lowry, K. 1989. Coastal area management: a Hawaii case study, p. 103-115. *In* T.-E. Chua and D. Pauly (eds.) *Coastal area management in Southeast Asia: policies, management strategies and case studies*. ICLARM Conference Proceedings 19, 254 p. Ministry of Science, Technology and the Environment, Kuala Lumpur; Johor State Economic Planning Unit, Johore Bahru, Malaysia; and International Center for Living Aquatic Resources Management, Philippines.
- Lowry, K. and H.J.M. Wickremaratne. 1988. Coastal area management in Sri Lanka. *Ocean Yearb.* 7: 263-293.
- Magoon, O.T., H. Converse, D. Miner, L.T. Tobin, D. Clark and G. Domurat, editors. 1987. *Coastal Zone '87*. Vols. 1-5. American Society of Civil Engineers, New York.
- Magoon, O.T., H. Converse, D. Miner, L.T. Tobin and D. Clark, editors. 1989. *Coastal Zone '89*. Vols. 1-5. American Society of Civil Engineers, New York.
- Maragos, J.E., A. Soegiarto, E.D. Gomez and M.A. Dow. 1983a. Development planning for tropical coastal ecosystem, p. 229-387. *In* R.A. Carpenter (ed.) *Natural systems for development: what planners need to know*. MacMillan, New York.
- Mattar, A. 1991. Coastal resources management: the Singapore experience, p. 83-90. *In* T.-E. Chua and L.F. Scura (eds.) *Managing ASEAN's coastal resources for sustainable development: roles of policymakers, scientists, donors, media and communities*. ICLARM Conference Proceedings 30, 125 p. Department of Science and Technology; Department of Agriculture; Department of Environment and Natural Resources; and Department of Tourism, Philippines; and International Center for Living Aquatic Resources Management, Philippines.
- McManus, J.W. 1988. Coral reefs of the ASEAN region: status and management. *Ambio* 17(3): 189-193.
- MOTI (Ministry of Trade and Industry). 1986. *Annual economic survey of Singapore*. Ministry of Trade and Industry, Singapore.
- Newman, H.E. 1991. The aquarium revolution and Underwater World Singapore, p. 117-119. *In* L.S. Chia and L.M. Chou (eds.) *Urban coastal area management: the experience of Singapore*. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines.
- Ng, P.S. 1989. *Singapore facts and pictures*. Ministry of Communications and Information, Singapore.
- Odum, W.E. 1976. *Ecological guidelines for tropical coastal development*. Working Group on Mangrove Ecosystems, International Union for the Conservation of Nature Commission on Ecology. (Mimeo).
- Olszewski, K.F. and L.S. Chia. 1991. National development, physical planning and the environment in Singapore, p. 185-205. *In* L.S. Chia, A. Rahman and D.B.H. Tay (eds.) *The biophysical environment of Singapore*. Singapore University Press, Singapore.
- Pang, K.M. 1987. *Coastal resources management with special reference to the Johor Straits in Singapore*. Geography Department, National University of Singapore. Academic exercise.
- Peet, G. 1988. Integrated management of sea areas: a condition or the protection of the marine environment. *In* Proceedings of the Annual Seminar of the Environmental Management and Research Association of Malaysia, 31 March-4 April 1988. Malaysia.
- PSA (Port of Singapore Authority). 1987. *Annual report*. Port of Singapore Authority, Singapore.
- Rahman, A. and L.S. Chia. 1977. A survey of oil pollution of water around Singapore, p. 208-230. *In* C.S. Hew and L.L. Koh (eds.) *Proceedings of the Symposium on Our Environment*. Institute of Natural Sciences, Nanyang University, Singapore.
- Rahman, A., L.S. Chia and S.P.D. Chung. 1980. Pollution of water by hydrocarbons and heavy metals around Singapore, p. 276-293. *In* C.S. Hew, K.L. Koh, L.M. Gan, Y.M. Sin and C.J. Koh (eds.) *Proceedings of the Symposium on Our Environment*. Institute of Natural Sciences, Nanyang University, Singapore.

References

- Snedaker, S.C. and C.D. Getter. 1985. Coastal resources management guidelines. Research Planning Institute Inc./National Park Service, USDI/United States Agency for International Development, Washington, D.C.
- Sorensen, J.C., S.T. McCreary and M.J. Hershman. 1984. Institutional arrangements for management of coastal resources. Institutional arrangements for management of coastal resources. International Affairs Office, United States National Park Service and the United States Agency for International Development.
- Soysa, C., L.S. Chia and W.L. Collier, editors. 1982. Man, land and sea: coastal resource use and management in Asia and the Pacific. Agricultural Development Council, Bangkok, Thailand.
- State of Hawaii-DPED (Department of Planning and Economic Development). 1982. Environmental impact statement for the Hawaii Coastal Zone Management Program. Department of Planning and Economic Development, State of Hawaii.
- Tan, P.B. 1991. Treatment of sludge and wastewater in Pulau Bukom, p. 69-75. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines.
- Teo, L.W. and Y.C. Wee. 1983. Seaweeds of Singapore. Singapore University Press, Singapore.
- Thomas, G.S.P. 1991. Geology and geomorphology, p. 50-88. *In* L.S. Chia, A. Rahman and D.B.H. Tay (eds.) The biophysical environment of Singapore. Singapore University Press, Singapore.
- Tiwari, S. 1991. Developing legal instruments for coastal area management of Singapore, p. 95-97. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines.
- URA (Urban Redevelopment Authority). 1989. Master plan for the urban waterfronts at Marina Bay and Kallang Basin. Urban Redevelopment Authority, Singapore. (Unpublished).
- URA (Urban Redevelopment Authority). 1991. Living the next lap: towards a tropical city of excellence. Urban Redevelopment Authority, Singapore.
- Valencia, M.J., editor. 1981. Proceedings of the Workshop on Coastal Area Development and Management in Asia and the Pacific, 3-12 December 1979. Manila. East-West Environment and Policy Institute, East-West Center, Honolulu, Hawaii.
- Wong, P.P. 1969. The changing landscapes of Singapore Island, p. 20-51. *In* J.B. Ooi and H.D. Chiang (eds.) Modern Singapore. Singapore University Press, Singapore.
- Wong, P.P. 1985. Artificial coastlines: the example of Singapore. *Z. Geomorphol.* N.F. 57: 175-192.
- Wong, P.P. 1991. Seaside resorts in Singapore: a geomorphological perspective, p. 109-116. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines.
- Yong, K.Y., S.L. Lee and G.P. Karunaratne. 1991. Coastal reclamation in Singapore: a review. *In* L.S. Chia and L.M. Chou (eds.) Urban coastal area management: the experience of Singapore. ICLARM Conference Proceedings 25, 128 p. International Center for Living Aquatic Resources Management, Philippines. p. 59-66

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- The coastal environmental profile of Segara Anakan-Cilacap, South Java, Indonesia.** A.T. White, P. Martosubroto and M.S.M. Sadorra, editors. 1989. No. 25, 82 p. \$2 surface; \$7 airmail; P25.
- The integrated management plan for the coastal zone of Brunei Darussalam.** Department of Fisheries, Ministry of Industry and Primary Resources, Brunei Darussalam. 1992. No. 29. \$2 surface; \$10 airmail; P50.
- The integrated management plan for Ban Don Bay and Phangnga Bay, Thailand.** Office of the National Environment Board, Ministry of Science, Technology and Energy, Thailand. 1992. No. 30, \$2 surface; \$10 airmail; P50.
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- The coastal resources management plan for South Johore, Malaysia.** Malaysian Coastal Resources Study Team, Ministry of Science, Technology and the Environment, Malaysia. 1992. No. 33, \$2 surface; \$10 airmail; P50.
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